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## ANALYSIS OF A TWITTERFEED COMMUNITY OF PRACTICING K-8 REFORM-MINDED SCIENCE TEACHERS

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ANALYSIS OF A TWITTERFEED COMMUNITY OF  
PRACTICING K-8 REFORM-MINDED  
SCIENCE TEACHERS

BY  
SUSAN P. UNGER

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE  
REQUIREMENTS FOR THE DEGREE OF  
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IN  
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AND  
RHODE ISLAND COLLEGE

2019

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RHODE ISLAND COLLEGE

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## ABSTRACT

Authors of Next Generation Science Standards suggest that to improve student learning in science, there should be an emphasis on “figuring out” science ideas rather than “learning about” science content. Teachers may likely need support in their attempt to implement these standards. Moreover, changes in pedagogy and classroom culture that facilitate implementation of NGSS could challenge science teachers’ identities. Research shows that professional development should be contextually based, sustained, and relevant. Recently, online platforms of professional development (PD) have emerged with affordances that can accommodate many of the aspects of effective PD. Twitter has been shown to be an effective vehicle for professional development for teachers.

This study analyzes the tweets and retweets of K-8 practicing science teachers in a Twitter feed community (@gemsnet10). The Twitter community is an offshoot of an established University-districts partnership (GEMS-Net) for the support of science teachers in their implementation of FOSS kit-based science curriculum. Data analysis explores themes, frequencies, and patterns of tweets and retweets using NVIVO qualitative software over five years of data. Individual profiles from users’ survey results illuminate the value of participation in @gemsnet10 for science teachers who were also members of GEMS-Net.

Results suggest that sharing codes prevail, and a possible connection to Gee’s theory of affinity identity (2000) was discussed as a theoretical underpinning of this phenomenon. Codes also emerge that reflect (a) teachers’ attempts at implementation of one or more of the dimensions of NGSS, and (b) pedagogical methods of teaching in general and science teaching in particular.

Findings support the possible use of a Twitter feed as a venue to provide sustained

and relevant PD for teachers in times of reform that strengthen science teacher identity, model pedagogical knowledge, and support implementation of NGSS. Members of the @gemsnet10 Twitter feed community used it most as a vehicle to acknowledge others, tweet about Science and Engineering practices (SEP), and share resources. The Twitter feed community in the present study is named as a Semiotic Identity Space (SIS), similar to Gee's Semiotic Social Space (SSS), but with important differences.

#### ACKNOWLEDGEMENTS

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# INTRODUCTION

Recently, significant developments have occurred in science education. The latest wave of reform was launched in 2013 with publication of Next Generation Science Standards (NGSS) for K-12. The NGSS are made up of three dimensions: Disciplinary Core Ideas (DCIs), Science and Engineering Practices (SEPs), and Crosscutting Concepts (CCCs) (see definitions in Figure 1.2) that work together to promote student understanding of science ideas (NGSS Lead States, 2013). To date, 24 States and the District of Columbia have adopted NGSS (see Figure 1.1).



Figure 1.1. States that have adopted NGSS by 2019. (nextgenscience.org)

As described in the Framework for K-12 Science Education (National Research Council, 2012), which outlines current guidelines for the latest wave of reform in science education, the goal of NGSS is that students increase their understanding of DCIs by using authentic science practices such as observation, asking questions, and defining

problems. Crosscutting concepts such as patterns and cause-and-effect are applied to data, as scientists do across many disciplines. Additionally, NGSS encourage teachers to adopt a role of “facilitator” as students build understanding of science ideas. Adjusting to the implementation of 3-dimensional science instruction will likely require substantial support for teachers.

Tyack (1991) proposed that the term “reform” has been used in many ways throughout the history of public education in the United States. He described waves of reform, each intending to solve a problem in the educational system or society at large. For the purposes of this study, I define the latest period of reform in science education as the period of time since the NGSS were published in 2013 until the present. For practicing science teachers today, the latest reform is the one that may likely define them and their identity as reform-minded teachers in science going forward. Furthermore, the present study is based in a State that was an early adopter of NGSS. In addition, GEMS-Net, the parent organization from which the Twitter feed community arose, is based in this New England State.

Teachers attempting to implement NGSS may need to adopt new pedagogies (Shulman, 1986). For example, rather than using direct instruction, facilitation of student-driven learning may demand tools such as a “driving question board” to encourage students to brainstorm proposed questions for investigation. Summary boards can be used to record understandings of students after a series of activities. Teachers implementing NGSS are guided by a series of learning progressions outlined in the Framework for K-12 Science Education (NRC, 2012).

Professional development (PD) will most certainly be needed to support teachers

through this journey. Tyack (1991) suggested that throughout the course of the history of reform in science education, reforms were less likely to be sustained if teachers were asked to change the way they teach. In addition, and equally as significant, science teacher identities may be altered when teachers are asked to enact reform, reinventing a new “teacher-self” (Zembylas, 2003) as teachers move into their new roles as facilitators of science learning in the implementation of NGSS.

### **Statement of the Problem**

Garet, Porter, DeSimone, Birman, and Yoon (2001) summarized the tenets of effective PD as long-term, ongoing, socially-constructed, and situated in context, in this case, classroom practice. However, high quality PD programs with characteristics listed above may be expensive to administer and maintain as well as difficult to attend because of constraints on teachers such as time or accessibility (Vavassuer & MacGregor, 2008). Yet technology offers affordances that may allow for collaboration and professional growth in PD (Archdichvili, Page & Wentling, 2002; Cho, 2016; Hanson-Smith, 2013; Hou, 2015; Johnson, 2001) to support teacher identity and pedagogy in times of reform defined in this dissertation as the period of time after the publication of NGSS. Since some digital platforms are free to join, they may circumvent budgetary concerns of other types of PD. Digital professional learning networks (PLNs) (Trust, Krutka, Carpenter, 2015) have the potential to address the concerns associated with implementation of reform and reconstruction of identity. McLoughlin and Lee (2008) recommended online settings for learner-managed collaborative professional development. Twitter is one type of digital social media that has been used for the purpose of communication among professional participants (Visser, Evering, & Barrett, 2014; Wesely, 2013).

Twitter is a micro-blogging digital platform that is free to use and offers many affordances. Users can tweet (share an original thought up to 140 characters, or 280 characters after November 17, 2018) or retweet (pass along tweets of others). Text, images, video, and hyperlinks can be added to post additional information. Hashtags can be used to tag a tweet or retweet. Mentions can be added to deliberately place a tweet or retweet directly to the account of another Twitter user (Twitter Guide Book, 2018).

In the past, several quantitative studies have shown positive results with using online platforms for PD (Carpenter, 2015). Carpenter and Krutka (2015) emphasized opportunities for personalization and collaboration in online platforms. Trust, Krutka, and Carpenter (2016) surveyed teachers who reported effective PD experiences using online platforms such as Twitter. However, none of these studies looked closely at Twitter data to gain first-hand impressions of the nature of teacher interactions in a Twitter feed community. In the present study, I used both qualitative and quantitative (mixed) methods to do an in-depth analysis of a Twitter feed community. It was by teasing apart the nature, frequency, and patterns of interactions of teachers that I began to get a true understanding of the nature of the community and its usefulness as support for implementation of teacher knowledge, NGSS, and for the formation of science teacher identity.

### **Purpose of the Study**

My aim for the present research study was to take a close look at a Twitter feed community that has existed since January 1, 2014, and is characterized by totally voluntary participation of teachers and other professionals. I examined frequency, patterns, and themes of tweets and retweets over a five-year span to look for evidence of

(a) references to NGSS DCIs, SEPs, or CCCs, (b) references to content knowledge, pedagogical content knowledge, and pedagogical methods, and (c) evidence of affinity identity among group members. I also asked teachers who were members of both the Twitter feed community and its parent organization to describe the value of participation in the Twitter feed community. Briefly, the parent organization, GEMS-Net, or Guiding Education in Math and Science Network, has been operating as a university-districts partnership for over two decades. One of their main goals is to support K-8 teachers in their use of FOSS kits for student learning in science. GEMS-Net launched a public Twitter account on January 1, 2014, with the username @gemsnet10. Participation in this community composed of teachers and other professionals has always been voluntary.

I chose to code five years of tweets and retweets for themes to discover the nature of teachers' interactions as well as possible changes of themes over time. I also looked for evidence to determine if the Twitter feed community had been used as a way of supporting teachers with implementation of Next Generation Science Standards (NGSS) in their own classrooms.

In addition, I viewed patterns of themes through a lens of identity, specifically to ask if teachers showed evidence of exhibiting "affinity identity" with other community members. Gee (2000) described "affinity identity" as gaining power through affiliation with a group. I wanted to learn if there was evidence that science teachers, through interaction in the Twitter community, could be strengthening their identity with the group who may also be attempting to implement reform in the science classroom.

## Definition of Terms

Terms used in this research study and their definitions can be found in Figure 1.2.

Next Generation Science Standards (NGSS)	Science standards for K-12 science education, consisting of 3 dimensions: Disciplinary Core Ideas, Crosscutting Concepts, and Science & Engineering Practices. Published in 2012. (NGSS Lead States, 2012)
Twitter	Twitter is a free social networking microblogging service that allows registered members to broadcast short posts called tweets. (Rouse & McMahon, 2015)
Twitter Community	Followers of @gemsnet10, a Twitter username founded as an offshoot of a University-Districts Partnership to support science teachers in student learning and implementation of NGSS.
Community	A group of people who share a common interest
Username	Unique designation for each user, starting with the symbol @
Tweet	Short posts, 140 characters or fewer. Note: After November 17, 2018, Twitter allowed up to 280 characters.
Retweet	Reposting or forwarding a tweet
Follower	A Twitter account holder who clicked “Follow” on the @gemsnet10 home page. If you “follow” a username on Twitter, you see the tweets and retweets of that user on your timeline. Followers each have a unique username.
Hashtag	A method of digitally collecting tweets or retweets in one place to share with other interested users and



	designated by a # symbol. For example, if a user tweets and includes the hashtag #education, other users can search that hashtag to find a group of tweets and retweets for that particular topic
GEMS-Net	Name for parent organization of the Twitter community in this research study
@gemsnet10	Username for Twitter community in this research study
New England University-Districts Partnership	An association between a mid-size New England University and the parent organization in this research study. One of the missions of this partnership is to support K-8 science teachers
NVIVO (11.4.2) 2018	Qualitative software for collection, analysis and visualization of data
Member	Member of GEMS-Net face-to-face PD community

*Figure 1.2. Definition of Terms*

## **Research Questions**

The proposed study will aim to analyze a voluntary long-term continuous Twitter feed community of practicing elementary science teachers to ascertain the nature and patterns of participation. Originally, I asked two main research questions which have remained intact throughout the course of this study. However, as I was collecting and analyzing data, other questions emerged. I added a third research question and sub-questions for questions 1, 2, and 3. Research questions and sub-questions are as follows:

1. What do reform-minded practicing teachers talk about in a Twitter feed community?

- 1.1 Are their online interactions professional versus personal in nature?
- 1.2 What themes are discussed in tweets and retweets? What does this suggest about why teachers are participating in this Twitter feed community?
- 1.3 Do community members make use of affordances of Twitter to connect specifically to other members or topics?
- 1.4 Is the community sustainable?
- 1.5 Do members perceive their participation as valuable? If so, why?
2. Are there patterns of participation for members of the @gemsnet10 Twitter feed community for five years of data collection that suggest changes in affinity identity or reform-minded pedagogy?
  - 2.1 Do frequencies of codes change over time?
  - 2.2 Do themes of codes change over time?
3. What do individual members report as the value of their participation in the Twitter feed community?
  - 3.1 Does this report triangulate themes of their coded tweets and retweets?

In the present study, I examined the tweets and retweets of a voluntary Twitter feed community of K-8 practicing science teachers and coded these tweets and retweets for themes. My goal was to summarize frequency and types of interactions to characterize the community's interactions as a whole. I also coded open-ended responses to a short survey to ask about participants' history on Twitter in general and about the value of participation in the @gemsnet10 Twitter feed community. All survey

respondents agreed to allow me to compile a User profile to summarize their interactions in the community. I encouraged all survey respondents to approve or edit this profile to accurately reflect the nature and value of participation in the Twitter feed community as a practicing K-8 science teacher, a process known as “member-checking” (Lincoln & Guba, 1985). The study contributed to research about PD by providing a close look at a possible model as a valuable platform for teacher learning, reform-minded practice, and the opportunity to build an “affinity identity” (Gee, 2000) with other teachers of K-8 science.

The chapters of this dissertation are organized as follows: In Chapter One, I describe a brief statement of the problem and outline the basic conceptual underpinnings behind my thinking about participation and value of the Twitter community for its participants. I also delineate research questions and sub-questions and define terminology for the reader. In Chapter One, I outline basic methodology and reasoning behind purposive selection of participants. Chapter One gives rationale for my lens of identity and Gee’s theoretical framework of affinity identity (Gee, 2000). I also briefly described methodology and discuss the significance of the study.

Chapter Two discusses pertinent literature in the research fields related to the study. Included in this body of literature I discuss communities of practice and professional learning networks, including those that are based on digital platforms. In addition, I evaluate research about teacher identity in general and science teacher identity in particular to set context for the digital community of practicing science teachers in this study. Carlone & Johnson (2007) formulated a model of science teacher identity and I adapted this model to the present study.

Chapter Three describes the framework for the methodology of this study. Included in this explanation is the rationale for selection of participants, the context of the study, and the reasons for choosing a mixed-methods design (Patton, 2002). I chose a case study with sub-cases (Yin, 2011) and justified content analysis (Richards, 2015) as methodology for coding themes of tweets and retweets. In Chapter 3, I described measures to help ensure reliability and validity of qualitative data as well as methods of ensuring confidentiality of participants and descriptions of methodology for inter-rater reliability (Patton, 2002). Chapter Three also provided a description of NVIVO qualitative software and its role in the data analysis of this study. I also included details about Twitter use and the capabilities of the Twitter platform. In addition, I offer rationale for the researcher's choice of survey questions and construction and platform for the survey. Most important, the chapter contains a step-by-step procedure for collection and analysis of the data and construction of the user and community profiles.

Chapter Four addresses the Twitter community as a whole to gain a sense of the characteristics of the entire community, including general descriptions about the community from all followers of @gemsnet10. I analyzed qualitative and quantitative data to describe the nature of interactions among @gemsnet10 followers for five years of data.

In Chapter Five, I constructed a user profile for each individual user who responded to the survey. The user profile is a compilation of a description of the type and frequency of tweets and retweets, examples of codes and how and why codes were applied. Survey data for each user revealed years of teaching and years on Twitter. Member-checking was used to validate user profiles.

Chapter Six discusses conclusions of the research study for the @gemsnet10 Twitter feed community as a whole with emphasis on the significance of the findings of the study for participants and developers of professional development. Specifically, I discuss future implications for practicing science teachers' use of Twitter as a possible venue for professional development.

The final section of Chapter 6 contains my reflections. I argue that the nature of the @gemsnet10 Twitter community consisted of a new type of entity which shares *some* characteristics of Gee's (2005) Semiotic Social Space (SSS). I maintain that the community of teachers brought together by this Twitter feed constitute a Semiotic Identity Space (SIS). Differences between SSS and SIS are thoroughly discussed. I describe the significance of the SIS for teacher-educators and professional developers interested in developing the identity of reform-based teachers.

## CHAPTER 2

### LITERATURE REVIEW

#### **Introduction**

In this chapter, I discussed a theoretical perspective that informed the current research study. I included theories of social learning and affinity identity to give context to the study. In addition, I evaluated theories of teacher identity and science teacher identity to frame this research and provide a model for building identity within the @gemsnet10 Twitter feed community.

Although this research study could have been approached through many different bodies of literature, I have set the context within a few main topics: (a) research about professional development for teachers, (b) research about professional learning networks in general, and online professional learning networks, in particular, and (c) use of Twitter communities organized for professional learning, especially for teachers.

As I evaluated pertinent research related for this study, I considered limitations of the research and considered how the present study adds value for teachers to the research base. I concluded Chapter 2 by outlining the research questions and sub-questions again.

#### **Theoretical Perspective**

Although this research can be viewed through many lenses, it was basically framed by Vygotsky's (1980) social-cultural theory of cognitive development, Lave and Wenger's (1991) theories of "situated learning," Wenger's (1998) ideas about "Community of Practice," and Gee's (2000) theory of identity, especially as related to reform-minded teachers (Luehmann, 2007).

Vygotsky's (1978) theories about the zone of proximal development are important as a model for learners in a social situation and were applied here to learning in a digital space. Vygotsky (1978) proposed that the process of learning includes both social and cognitive components. The learner relies on social clues to evaluate the significance of new cognitive information. When a more competent peer or adult presents information to a learner, the learner evaluates ways in which any new information relates to former knowledge. According to Vygotsky, learning happens as the result of a connection to new information that may have previously been out of reach cognitively, has been shown to be socially significant by a more competent peer, and is deemed by the learner to be relevant.

In context of the present research study, one possible model for learning is that when information is shared among teachers in a Twitter feed, the information may be evaluated by other potential learners for significance. Members of the Twitter feed community may experience changes in pedagogy or identity from learning that occurs due to their associations with other members of the GEMS-Net Twitter community.

Likewise, Lave and Wenger (1991) also proposed a social model of learning. Their model of "situated learning" (where learning occurs in a context, embedded in practice) suggested that learning takes place within a community of members with a range of levels of competency. They contended that whether an individual was central to the community, i.e., had a role of leadership, or whether an individual had a more peripheral role as an observer, or anywhere in between, all positions in the community were valuable to participants, because they offered opportunities for learning. Furthermore, individuals could move from peripheral to more central roles as their

confidence and abilities increased. Lave and Wenger's description of "situated learning" as dynamic, legitimate, and contributory to the community provided a framework for the Twitter community in this proposed study. The present research characterized the nature of the entire @gemsnet10 Twitter feed community for five years of data collection. Analysis of interactions, both in terms of frequency and theme, revealed similarities and differences among members and their perceived value of participation within the community.

Wenger (1998) described a model for social learning within a Community of Practice (CoP). He described a CoP as a group of people with shared goals, domains, and a common language. This model could be applied to the @gemsnet10 members since the community was formed from a parent organization of K-8 science teachers who likely fit Wenger's description.

Another valuable theoretical frame for this study came from Gee's (2000) theory of how identity is formed. In his words, identity is "The 'kind of person' one is recognized as 'being,' at a given time and place, can change from moment to moment in the interaction, can change from context to context, and, of course, can be ambiguous or unstable" (Gee, 2000, p. 99).

Gee (2000) described identity as "fluid" and "situated," providing examples of the same individual having different identities within a variety of contexts simultaneously. Gee emphasized that identity does not exist as a static manifestation of our relationships as, for example, we do not maintain a set identity as a "parent" or "sibling." Gee theorized that identity goes beyond simple categories such as race or class. He described four types of identity: nature identity from the forces of nature, discourse identity from



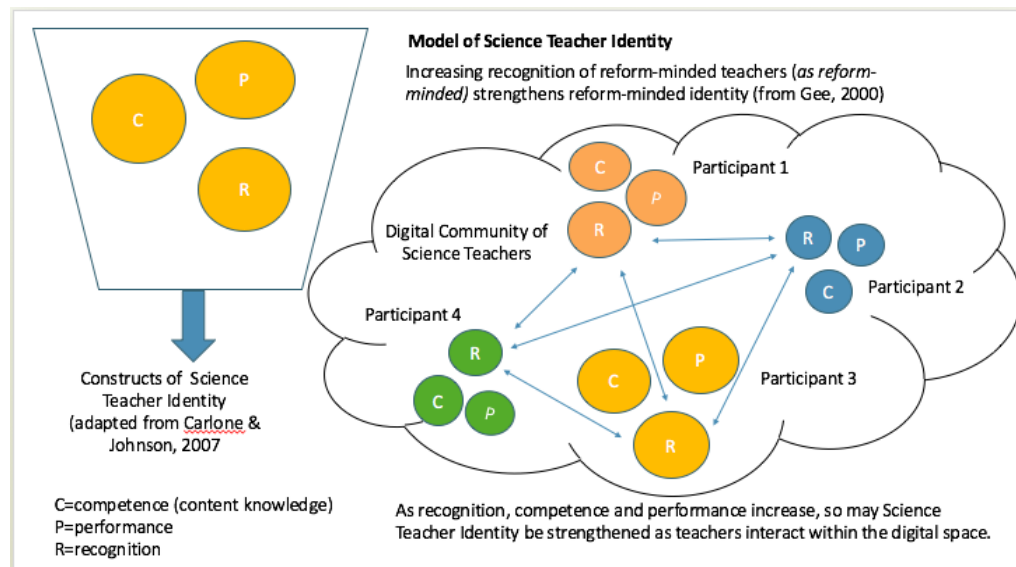
discourse with others, institutional identity which comes from authority figures of institutions, and affinity identity whose power comes from affiliation with a group.

Although Gee offers a solid frame for the identity of each participant in the proposed study, Leuhmann's insights about risks inherent in teachers who adopt reform-minded identity provides even deeper insights related to possible changes in identity within the group of participants of this research.

Luehmann (2007) proposed that science teachers considering the implementation of reform experience may have feelings of risk inherent with assuming the new identity of a reform-minded teacher. Leuhmann, like Gee (2000), described identity is fluid and contextual, similar to Lave and Wenger's (1991) description of "situated" which they described as contextual. Additionally, Luehmann suggested that the process of incorporating a reform-minded identity into a former teacher identity would increase in risk as the conceptual distance between former and new teacher identities increased. If this is so, teachers would presumably need more support as they struggled with finding aspects of reform-minded identity that were close enough to their former "teacher-selves" (Zembylas, 2003) to be worth the risk of adopting.

The social interactions within a shared digital space such as a Twitter feed community may provide a safe space for assuming new reform-minded identities to decide if they can be incorporated into a participant's former identity of "teacher-self." Participants are able to view and comment on posted tweets and retweets of fellow participants to evaluate shared ideas and perspectives. Community members whose practice is more reform-minded can share pedagogies with less-reform minded members, eventually developing a more reform-minded identity in the latter group.

Carlone and Johnson (2007) and Perrault (2017) hypothesized that science identity, in students, career women, and underserved populations, was composed of at least three core constructs: (a) competence, which is defined as knowledge and understanding of science, (b) performance, which is based on social observation of a person “doing” science or acting and speaking like a scientist, and (c) recognition, defined as being seen as that “type of person” by others (Gee, 2000) (see Figure 2.1).



*Figure 2.1.* Adaptation of Carlone and Johnson’s (2007) model to incorporate a digital context of reform. Participants 1-4 are located in a “digital cloud.”

I adapted Carlone and Johnson’s model for the development of science teacher identity for teachers in this study. In this adaptation, competence has been defined as the ability to successfully implement pedagogy that results in increased understanding of science by students. Performance is defined by how teachers implement systems such as classroom management techniques to facilitate student understanding. Recognition in the development of science teacher identity can be defined as how students, peers, and administrators acknowledge the capabilities of a person in their role as a science teacher.

Using the affordances provided by a digital space, the formation of science teacher identity may be facilitated for a few reasons. First, identities of more than one science teacher may exist in a mutual, free, and relatively safe “space.” If participants agree to exist in this space, regardless of their level of participation (Lave & Wenger, 1991), the possibility of recognition of other participants’ reform-minded work may increase due to opportunities to observe fellow participants in the Twitter feed community long after the cessation of interactions from face-to-face PD. Second, social interactions among participants can happen synchronously or asynchronously, meaning that although participants may tweet or retweet at any time, “chats” can be scheduled to occur simultaneously with other participants if the same hashtag is used to gather tweets in the same digital space.

I hypothesize that a possible result of interactions of practicing science teachers in a Twitter community is that any member of the community may become more competent in content knowledge as a result of these interactions. The Twitter community from this study, @gemsnet10, was formed the year after NGSS were published. The parent organization that launched @gemsnet10 uses a FOSS kit-based system for teaching science that is aligned with NGSS. Teachers from the parent organization (GEMS-Net) have also met face-to-face for PD that supports implementation of kits in their classrooms, a practice that has been shown to produce science instruction that is over 90% accuracy in science content (Nowicki, Sullivan-Watts, Shim, Young & Pockalny, 2013). Interactions within the @gemsnet10 may help to support face-to-face PD for science content.

Members of @gemsnet10 may also incorporate elements of others’ work to better

their own performance as a science teacher and be recognized by community members as a science teacher (Carlone & Johnson 2007). These factors together (performance, recognition, and competence) may influence, or possibly strengthen, science teacher identity as proposed by Carlone and Johnson (2007).

Participating science teachers may strengthen their science teacher identity as they allow other participants to view, comment and share tweets. Whether posting or observing, or a combination of the two, the possibility of recognizing, commenting, or sharing the work of fellow community members allows for recognition of tweeters as “doing” science, using science vocabulary (that is, speaking like a science teacher), as well as highlighting the valuable or noteworthy science work of others. Especially important, participants may adopt new pedagogical methods as a result of their participation of the Twitter feed as they “view” other reform-minded teachers “at work.”

For content knowledge, a participant in a Twitter-based community of science teachers may gain, augment, redefine, or share content with other members as a result of interaction within the same digital space. Likewise, participation affords the opportunity to view digital records of others’ performances as science teachers.

Since 2012, Twitter may be used to support reform-minded identities of teachers who are attempting to implement NGSS by allowing others within their teaching communities to perceive them as reform-minded implementers of NGSS (as the work of Carlone & Johnson, 2007 suggests). Twitter communities may at least partially fulfill the role of support of teachers as they take on a new reform-minded identity and leave a former identity behind. A digital community such as the Twitter community for this proposed study is free for participants and may asynchronously allowing communication

among reform-minded teachers who are seeking support to implement reform. Using digital tools to see how implementation of NGSS works in other classrooms, viewing student work as the process unfolds, and being digitally “present” in the process of watching other reform-minded science teachers acknowledge the good work of themselves and others will be a valuable way of adopting a new identity as a reform-minded teacher who is working to implement NGSS. Moreover, a teacher who is a part of a reform-minded community does not even have to share her own ideas. Especially at first, even viewing the digital community will be valuable to adopting reform-minded identities.

### **Relevant Research**

**Professional Development.** Borko (2004) recommended that professional development (PD), as a research area, demands a variety of assessment tools over multiple contexts to make generalizations about effectiveness of different types of programs. Grossman (2008) suggested that it would be helpful to evaluate alternatives to traditional professional development programs for effectiveness in teacher learning. To date, some generalizations have been made from results of past research in these areas.

Several research studies have contributed to our knowledge about effective PD. An Educational Brief published more than a decade ago (Kedzior & Fifield, 2004) suggested that collaboration was crucial for good PD. Likewise, teacher choice was valuable for both the content and the process by which content is delivered. In addition, PD should be ongoing and coherent in format. Finally, the opportunity for self-reflection at various times throughout the program is essential for processing of new information. Professional development seems to be more useful when the teacher is allowed to tailor

their learning to fit their own needs. Garet et al., (2001) suggested that content of PD should be connected to the subject matter of the teacher's practice. Professional development has been found to be more effective when long-term (Birman, Desimone, Porter, and Garet, 2000) even though professional development has traditionally been doled out in short-term sessions with a one-size-fits-all approach. Admittedly, sessions that take place in the timeframe of one day or less have the advantage of being more budget-friendly.

Other research investigated how to sustain learning from PD programs. Coburn, Russell, Kaufman, & Stein (2012) suggested that social networks may contribute to new learning from face-to-face PD, especially in the case of reform-related information. When teachers were trained to implement a new educational program, those teachers who had access to a social network were more likely to implement this program for at least two out of the three year window of data collection when administrative supports were withdrawn.

Fogleman, Fishman, and Kracjik (2006) also reported that long-term support of teacher leaders' efforts to grapple with anticipated issues of implementation of science units was instrumental in leading to an organic formation of a discourse community which evolved into a community of practice. Lead teachers in this study were provided with enough time to build relationships with colleagues. Teacher learning happened in a situated context. In time, teacher leaders developed shared language and common goals. It was suggested that support in the form of training sessions for these teachers could be gradually withdrawn without jeopardizing their ability to implement the science units. In short, situated long-term professional development would be sufficient to sustain teacher

learning in a time of reform.

Similarly, Kintz, Gotwals, and Cisterna (2015) showed that for deep discussions to take place in PD, a mentor was helpful to provide scaffolding necessary to support learning with colleagues.

**Professional Learning Networks.** Boylan, Coldwell, Maxwell, and Jordan (2018) reviewed research about professional learning. They concluded that there were five categories of models of widely accepted professional learning. Four models solidly highlight teacher learning as occurring in a social context, even describing the process as constructivist in one model (Clarke & Hollingsworth, 2002). Several studies reported some kind of sociological component (Clarke & Hollingsworth, 2002; Desimone, 2009; Evans, 2014; Guskey, 2002; Opfer & Pedder, 2011). Notably, however, Evans (2014) can be set apart for describing teacher learning as mostly cognitively-oriented and dependent on levels of teacher agency and teacher outcomes.

Campbell and Dunleavy (2016) suggested the importance of context in professional learning. Working with teacher candidates, they took a non-traditional approach to teacher learning. The researchers conducted field studies in mathematics with both teacher candidates and teacher educators. One of the goals was to allow teacher candidates the chance to experience how their future students access mathematics using various activities and located in various settings. Candidates were able to observe many teaching methods as well as methods that emphasized equitable teaching practices. Teacher educators of language arts also conducted methods classes in middle school classrooms. Research suggested that both informal and formal settings were valuable for teacher learning.

LeCornu and Ewing (2008) suggested that there is a need to move away from traditional emphasis on teacher practice alone to include both reflection on practice as well as collaboration with other colleagues. The authors recommend participation of preservice teachers in learning communities of peers to give these novice teachers the opportunity to learn from each other. In addition, LeCornu and Ewing suggested that questions and problems that arise can be brought to mentors for help with solutions. Most importantly, they allowed for the possibility that all parties would benefit from a reciprocal relationship where both preservice and mentor teachers learn from each other. In the next section, I will further investigate research on professional learning networks that are at least partly based online.

**Online PLNs.** Darling-Hammond and McLaughlin (1995) suggested that, in times of reform, professional development should involve collaboration and sharing of ideas to support new learning for teachers. They recommend that school administrators should establish policies to allow this to happen.

Digital platforms allow for a digital space that has the capacity to connect participants of online communities. With the advent of this technology, teachers have the opportunity to share ideas, ask questions, showcase exemplary work and learn from colleagues. Moreover, there can be synchronous and asynchronous communication 24 hours per day.

Several studies documented teacher learning in the context of online platforms, some comparing online PD to face-to-face. Lee and Brett (2015) documented teacher transformative learning that occurred through online discussions in a graduate-level course. Fishman et al., (2013) randomly sorted teachers into two types of PD, online and



face-to-face. They measured teacher knowledge and beliefs, teacher classroom practice, and student learning outcomes. The PD content was centered around common curricular materials. Researchers found significant gains in student learning for both conditions. From this study, there was some indication that method of delivery of PD may not be a significant factor in professional development.

A particularly relevant study for the current research project was conducted by Liu, Miller, and Jahng (2016). They focused on participatory media, e.g. Blackboard, EduBlogs, VoiceThread, Ning, as a way of extending face-to-face workshops about East Asian studies. The researchers used observations, interviews, online discussions and curriculum products as data sources. Data were coded and validated through comparison to multiple sources and using multiple raters.

The researchers found evidence that teachers collaborated within and across cohorts to extend learning in online communities. Participants reported not only new knowledge about East Asian studies, but an increase in “professional capital,” (p. 9) meaning that learning from these PD workshops allowed some participants to assume new identities as experts of East Asian studies within their schools and districts. Participants also reported finding a voice within their new online communities, suggesting a connection to the present research study, that of a new “affinity identity” (Gee, 2000) with other members of their group.

Notably, participation in online communities was not without impediments. Liu et al., (2016) reported that unequal levels of participation seemed to produce reluctance to contribute for some members who reported that they were reluctant to participate in their online communities because of other members who were frequent contributors. Other

participants reported problems with internet access.

Researchers eventually helped participants develop a Ning that allowed for a variety of online activities which led to a voluntary and sustainable community of practice. This site was used to promote interactions across international communities.

**Twitter-based PLNs.** Twitter is a public microblogging platform that is free to access and use (Twitter Guide Book, 2018). Participants of Twitter, identified by “usernames,” communicate using 140 characters (until November 17, 2018) as well as hyperlinks, images, and video. Users choose to write original posts (Tweet) to their “Followers” or share posts from those they “Follow” to their followers (Retweet). Users can target messages to groups interested in specific topics through the use of hashtags and they may also tag users in a post by including a username of the person they are tagging. Users can be asynchronous or choose to “chat” at a predetermined time to exchange ideas on a common domain. For the purposes of this study, users will be considered participants if they tweet, reply, retweet, or report that they observe the tweets of others.

Definitions of community of practice originated with Wenger (1998). Recent definitions often include a group of people with shared goals and values located in a particular geographical area. This definition was adapted to the digital community in this study. Rather than having a geographic area as a boundary for the digitally-based Twitter community, the boundary was determined by the “followers” of a username.

Sussman (1977) described a community as a serving the goals of individuals as well as the entire group. Since participation is voluntary for members of the Twitter community in this research study, it seems likely that continued participation happens for individual users because these individuals are in some way meeting their own goals as

well as aligning with the goals of the parent organization, @gemsnet10 or they would likely not participate.

It should be noted that there are some barriers to professional learning in online communities. Tsai (2012) reported that if participants of an online community were uncomfortable using technology, this impacted their sense of community and satisfaction, inhibiting learning. Archdichvili, Page and Wentling (2002) found that some employees of a corporation reported a reluctance to share information because they were not confident that the information was valuable for other employees in the online community. Others practiced “information hoarding” described as deliberately withholding valuable information (p.11) from other community members.

However, because of affordances offered by online platforms, such as the possibility of synchronous as well as asynchronous communication, online communities have been shown to be helpful for teachers in need of timely support (Ebenezer, Lugo, Beirnacka, and Puvirajah, 2003). Specifically, the responsiveness of the platform allowed for a quick reply. In addition, Hanson-Smith (2013) suggested that participation in online communities can enhance the process of archived information that is valuable to the group. Hou (2015) found that online pre-service teachers had vivid recall of information when they discussed and “figured out” issues that arose during practice-teaching. The process of “figuring out” aligns (Mathewson, 2017) with the approach of implementers of NGSS (NGSS Lead States, 2013).

Moreover, some participants may feel more comfortable contributing to an online group discussion rather than a face-to-face setting. Johnson (2001) reported that “online communities had a possible benefit over face-to-face groups in that all members felt

included because [the former] environment suppresses traditional group norm behavior.”  
(p. 12)

**Teacher Identity.** The process of identity formation is ongoing (Gee, 2000, Zembylas, 2003) and is responsive to many mediating factors. The construct of identity has been difficult to characterize. For example, Boylan and Woolsey (2015) described the construction of identity as moving through psychosocial space between fixed points that are in relation to each other. For teachers, experiences such as the practice of teaching, communication with colleagues and students, and interactions in contexts of professional learning (Wenger, 1998) are a few of the ways that teachers construct their professional identities (Adams & Gupta, 2015). Beijard, Verloop, and Vermunt (2000) found that some secondary teachers reported a change of identity as they moved from an emphasis on content to becoming more adept at pedagogy throughout their years of teaching. In addition, the researchers suggested that written reflections about the practice of teaching have been suggested to have a profound effect on identity. Alignment with other like-minded teachers was found to help teachers shape identity.

Research suggests that if teachers choose to change their identity to one that incorporates reform, dissonance between former and newer identities may be uncomfortable at first (Akkerman & Meijer, 2011; Leuhmann, 2007). Moreover, inherent in this process is perception of risk in taking on a new reform-minded teacher identity (Leuhmann, 2007). This evidence holds significant implications for professional development. Leuhmann’s (2007) research implies that professional development should be flexible and responsive enough to allow identity transitions to be facilitated as teachers negotiate the process of adopting new identities in their teacher practices, especially

during educational reform. Affinity identity formation (Gee, 2000) with a reform-minded group could also facilitate this process of seeing oneself as reform-minded and having others recognize reform-minded identities in colleagues (Leuhmann, 2007).

Flint, Zisook, and Fisher (2011) emphasized the importance of long-term professional development as support for building identity as a teacher. Researchers conducted observations and interviews of two teachers over a three-year period. Through this long-term support, teachers reported a new sense of agency and a renewed sense of identity. Receiving support for an extended amount of time allowed teachers to develop caring relationships with their mentors which contributed to their identities as professionals. Flint et al. emphasized that both mentors and teachers shared ideas and information. Teachers had a chance to critique and reflect on their own work and were encouraged to choose professional goals for themselves. Confidence in their own learning seemed to transfer to the relationship that the teachers had with their students.

Reform-mindedness can be defined in many ways. Leuhmann & Tinelli (2008) defined a reform-minded teacher as one who sees herself, or is seen by others, as reform-minded (see Appendix A). Cochran-Smith (1991) defined a reform-minded teacher as a teacher who is outside of the norm. In other words, reform-mindedness, according to Cochran-Smith, would be the teachers who are early adopters of the latest reform movement, in this case, the earliest to adopt NGSS. For the purpose of this study, a reform-minded teacher is a teacher who is in the process of implementing NGSS, or who is seen by others as attempting to adopt NGSS for use in their classroom. The Twitter community of practicing teachers from this study is designated as reform-minded because the curriculum, and supporting face-to-face professional development of the parent

organization from which the Twitter feed community was formed aligns with NGSS. However, individual participants may be more or less reform-minded as evidenced by the content of their tweets related to NGSS.

**Science Teacher Identity.** Science teacher identity has recently been the subject of research in both classroom settings (Avraamidou, 2014a) and informal settings (Avraamidou, 2017). For this proposed study, science teacher identity will be defined as “the ways in which a teacher represents herself through her views, orientations, attitudes, emotions, understandings, and knowledge and beliefs about science teaching and learning.” (Avraamidou, 2014a, p. 5).

Volkman and Anderson (1998) considered the study of teacher identity to be critical if we are to understand how to support teachers in constructing teacher identities. For example, conflicts arose when a first-year chemistry teacher constructed antithetical roles of seeing herself as an adult versus a student. She struggled with acting in a caring way versus being “tough” with her students. She was concerned about fulfilling her expectations about her teaching role in contrast to the role others assigned her.

Avraamidou (2014b) emphasized that although science teacher identity is complex and contextual, researchers should attempt to define and understand it as a way of supporting science teacher identity in both classroom settings (Avraamidou, 2014a) and informal settings (Avraamidou, 2017). For this proposed study, science teacher identity will be defined as “the ways in which a teacher represents herself through her views, orientations, attitudes, emotions, understandings, and knowledge and beliefs about science teaching and learning.” (Avraamidou, 2014a, p. 5).

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**Need for Further Research.** From past research about the importance of science teacher identity, long-term relevant and responsive professional development, and support for teachers attempting to implement reform-based science education, there was a need to examine Twitter use by teachers as a possible way of supporting these important goals. The present study took a close look at a Twitter feed community that has been in existence since January 1, 2014. The parent organization of the Twitter feed community, @gemsnet10, aligns its curriculum and hence its offering of face-to-face professional development with NGSS using a FOSS-kit based curriculum. The Twitter community is also aligned with NGSS and is, by definition of its mission, reform-minded. Past research has called for long-term PD that is relevant to the user and has a social network of support to sustain learning. Teachers have described this Twitter community as valuable for several reasons, including staying connected to the parent organization.

In summary, the present study filled a gap in the relevant literature by providing an analysis of the nature and frequency of teachers’ interactions in a Twitter feed community to find evidence of (a) support for science teacher identity (b) support for implementation of NGSS, and (c) value of participation in the @gemsnet10 Twitter feed community for teachers who are also members of the parent organization, GEMS-Net.

## **Unique Contribution of the Present Study**

The present study made a unique contribution to research on PD in times of reform for a few reasons. The qualitative nature of this study allowed me to closely analyze the nature, frequency, and patterns of interactions of an entire Twitter feed community to look for references to NGSS-based science reform as well as to find evidence of teachers building science teacher identities in a reform-based era. In addition, I examined themes of tweets and retweets to look for themes related to general pedagogical methods, content knowledge, and pedagogical content knowledge. This in-depth approach to analysis of an online professional Twitter feed community offered insight about online teacher support that could possibly be helpful for building science teacher identity and implementing NGSS for other practicing teachers in times of reform.

## **Research Questions**

Research questions for this study are closely related to the theoretical frameworks that are mentioned in this chapter. I specifically searched for valid evidence that participants of the @gemsnet10 Twitter feed community were making connections with other teachers for professional reasons related to teacher practice. Looking even further, I searched for evidence of identity-building interactions within interactions of teachers. For example, did teachers participate by sharing ideas, pedagogical knowledge, or resources? The act of sharing may contribute to a stronger affinity-identity with other members of @gemsnet10, according to Gee (2000). Did teachers share practices that are aligned with NGSS, perhaps to be recognized as reform-minded and develop a reform-minded science teacher identity (Carlone & Johnson, 2007)? Did a pattern of codes evolve over time suggesting a change in the type of interactions? To explore these



possibilities, the following research questions evolved:

1. What do reform-minded practicing teachers talk about in a Twitter feed community?
  - 1.1 Are their online interactions professional versus personal in nature?
  - 1.2 What themes are discussed in tweets and retweets? What does this suggest about why teachers are participating in this Twitter feed community?
  - 1.3 Do community members make use of affordances of Twitter to connect specifically to other members or topics?
  - 1.4 Is the community sustainable?
  - 1.5 Do members perceive their participation as valuable? If so, why?
2. Are there patterns of participation for members of the @gemsnet10 Twitter feed community for five years of data collection that suggest changes in affinity identity or reform-minded pedagogy?
  - 2.1 Do frequencies of codes change over time?
  - 2.2 Do themes of codes change over time?
3. What do individual members report as the value of their participation in the Twitter feed community?
  - 3.1 Does this report triangulate themes of their coded tweets and retweets?

## **Summary of Chapter 2**

Literature suggests that PD should be sustained, contextually relevant and exist in a social framework to best sustain teacher learning. Yet, the one-size-fits-most approach continues as the most prevalent form of PD, possibly due to budgetary and scheduling

concerns. Online platforms for PD have affordances that allow accessibility as well as affordability. Twitter is public and free for users. Online professional learning communities have formed to meet teachers' pedagogical needs and provide support for fostering teacher and science teacher identity.

The community from the present research study is unique in that participation occurs on two levels for many participants, both face-to-face and online. This provides an interesting opportunity to uncover patterns and types of interactions.

## **CHAPTER 3**

### **METHODOLOGY**

#### **Introduction**

In Chapter 3, I discussed the methodological basis for this research study. I explained specific research questions and sub-questions, along with operational definitions for all questions. I specifically discussed the unique nature of the parent organization for participants of this study and its relationship to participants as well as the criteria for participant selection. I explain the rationale for the choice of case study design as well as reasons for delineating sub-cases (Yin, 2011). Furthermore, I justified content analysis (Fraenkel, Wallen, & Hyun, 2011) as a method of data analysis to categorize themes of tweets and retweets. I explained the process of constructing a brief survey to triangulate coding of themes of tweets and retweets of survey respondents as well as the process for construction of a profile of the entire community.

Qualitative analysis software and the detailed coding process is included in a table that outlines procedural steps. Procedures for protection of the identities of participants are described. In addition, I disclose the procedure to confirm acceptable levels of inter-rater reliability measures to further validate themes of tweets and retweets.

#### **Meet the Researcher**

Interest in this research, for the most part, comes from my own serendipitous experience as a science educator for nearly 15 years. In 2003, I was asked to teach science at a small private school in which my own children attended. At this point in time, I had an advanced science degree and a research career that spanned over a decade in six science laboratories (academic, industrial, and medical settings) with no aspirations

of classroom teaching. I was content to volunteer as a mentor to students for activities such as science fair and often participated in lab activities at the request of teachers. When the middle school science teacher left, an administrator asked if I were willing to take on this position. She confided that she needed a teacher with content knowledge as well as enthusiasm for the discipline of science. She was looking to hire a person with demonstrated ability to engage with students and who was invested in the community. Needless to say, I naively agreed to take on this monumental task in spite of the fact that I did not have the benefit of teacher preparation classes. Ultimately, my role expanded to include science classes for grades K-8.

To compensate for my lack of pedagogical expertise, I attended every possible session of professional development that was available to me. I realized that it was important for me to glean ideas, lesson plans, and resources from teachers who were more experienced than I. I was willing to connect with other science educators, both locally and nationally, whenever possible. Especially in the beginning of my teaching journey, I felt isolated and lacked confidence in the myriad decisions I had to make regarding curriculum, pedagogy, assessments, etc. I lacked a reliable network of science teachers to fall back on. I tried on different types of “science teacher identities” gleaned from my own memories as a student, from online and other resources, from professional development sessions, and from my own evaluation of student learning in my classroom.

Looking back over the experience, I struggled most with the question of what type of science teacher I wanted to be. Would I rely on methods from traditional classrooms from my past? Would I model myself after an extremely dynamic high school science teacher who mixed traditional pedagogies with authentic science projects such as

collecting samples from a nearby lake as a basis for lessons on environmental science? How would I assess learning? Throughout the years of trial and error, peppered with ideas from professional development and modeling myself after various teachers I met along the way, I fought the constraints of isolation and formulated a curriculum from current standards, ultimately designing curriculum altered by my own assessments of student learning and feedback.

When Next Generation Science Standards were published in 2013 (NGSS Lead States, 2012), I grappled with how to interpret and implement them with my own students. Again, I sought models of how teachers were attempting to implement new standards. I collected ideas and resources, sometimes at great expense of money and time away from my family, to make decisions about what an NGSS-based curriculum was all about.

When the opportunity presented itself through this Ph.D. program to research a long-standing voluntary Twitter feed community that began with a goal of supporting science teachers, I appreciated the opportunity to take a close look at the community. What were they talking about? What types of interactions did they share? Did themes of discussion change over time? Would patterns of interactions be revealed? What value did participation in this Twitter feed community have for these teachers and their professional practices? Some participants in this community also meet periodically in face-to-face professional development sessions at least once per year. Did they enact different patterns in frequency of participation in the Twitter feed community if compared to teachers who only were associated online?

Of particular interest to me, would community members use the Twitter platform

to share ideas about the latest wave of reform in science education, the Next Generation Science Standards? And generally, would I find evidence that Twitter is a valuable digital tool for professional development in this community, a way to connect with other Twitter feed community members for support in a period of reform in science education post publication of NGSS? Would teachers reveal their pedagogical techniques, content knowledge, and methods of pedagogical content knowledge to others in this digital community? Would they report that participation in this community was a valuable professional experience in some way? My research was an attempt to search for patterns of types and frequency of interactions that might suggest teachers found value in this professional community for their own identities as reform-based teachers (i.e. implementors of an NGSS-designed curriculum). The implication is that the community could possibly be upheld as a model for professional development for other science teachers, especially in times of reform.

In summary, this research does not follow the approach such as espoused by grounded theorists. I had an agenda going in, which was to find evidence for a way to support teachers in their professional practices that would be relevant to them. Codes were viewed through lenses of Gee's (2000) affinity identity, which was defined previously as identity that gains power through affiliation with a group. Codes were also viewed for evidence of reform-mindedness, which was defined as openness in implementing the latest approach to science education, NGSS. In other words, did codes reflect a willingness to share or comment upon ideas that showed a connection to NGSS-aligned terms, practices, and activities, either in text, image, video, or hyperlink?

## **Research Questions**

Because of my interest in taking an in-depth look at the frequency and type of interactions within the @gemsnet10 Twitter feed community to consider its usefulness as a model of professional development, especially in times of reform, I formulated the following research questions:

1. What do reform-minded practicing teachers talk about in a Twitter feed community?
  - 1.1 Are their online interactions professional versus personal in nature?
  - 1.2 What themes are discussed in tweets and retweets? What does this suggest about why teachers are participating in this Twitter feed community?
  - 1.3 Do community members make use of affordances of Twitter to connect specifically to other members or topics?
  - 1.4 Is the community sustainable?
  - 1.5 Do members perceive their participation as valuable? If so, why?
2. Are there patterns of participation for members of the @gemsnet10 Twitter feed community for five years of data collection that suggest changes in affinity identity or reform-minded pedagogy?
  - 2.1 Do frequencies of codes change over time?
  - 2.2 Do themes of codes change over time?
3. What do individual members report as the value of their participation in the Twitter feed community?
  - 3.1 Does this report triangulate themes of their coded tweets and retweets?

## **Research Design**

To reach my research goals, as delineated in research questions and sub-questions,

I chose a mixed methods approach. Specifically, this study can be characterized as a convergent parallel mixed methods study. This type of methodology is defined as using qualitative and quantitative data analyzed in parallel with information from both types of data converging to yield interpretation of results (Creswell, 2014).

Qualitative data analysis was used primarily in this study to characterize the nature of the themes of interactions of members of the @gemsnet10 Twitter feed community. Qualitative data provides the researcher with the opportunity for an in-depth analysis of participants' experiences to further our understanding of the experiences (Patton, 2002). Five years of Twitter data (671 tweets and retweets) provided a source of rich data for this research.

Many studies involving professional collaboration of participants in online communities have gathered relatively larger samples of quantitative data from surveys administered online within the community (Fishman et al., 2013; Carpenter, 2015; Carpenter & Krutka, 2015; Trust, Krutka, & Carpenter, 2016). However, quantitative data may not optimize the opportunity to delve into themes and sub-themes from the participants of the Twitter feed community as well as to take a closer look to ask, "What was the intention of the tweeter or retweeter? Does any accompanying information from images, videos, or hyperlinks confirm my interpretation about the original intention of the tweet or retweet? What theme characterizes the intention?" Therefore, a qualitative approach was used to answer these types of questions. Data from qualitative analysis was used to answer research questions 1, 1.1, 1.2, 1.3, 1.5, 2.2, 3, and 3.1.

Yet, quantitative data analysis was also useful in conjunction with qualitative data analysis to give a clearer characterization of the Twitter feed community. In conjunction



with characterization of tweets and retweets, quantitative data was used to graph trends of changes in codes over time, for example. Quantitative data analysis was used to answer research questions 1.4, 2, 2.1, and 2.2. Please note that I used both qualitative and quantitative data to answer question 2.2.

Qualitative analysis of data was conceptualized specifically as a case study with the whole case consisting of all of the Twitter data. The entire Twitter feed community was further subdivided as sub-cases consisting of specific members of the Twitter feed community, @gemsnet10. Specifically, I chose a case study design with subcases.

### **Case study design**

I conducted the qualitative part of this research study as a case study (Yin, 2014) where the case consisted of the entire online Twitter community of @gemsnet10 including their tweets, retweets, images, video and hyperlinks posted to Twitter.com from January 1, 2014 to December 31, 2018. There were a total of 671 tweets and retweets during this time period. It was never my intention to manipulate conditions in any way that might affect the nature, type, or frequency of interactions of participants in the @gemsnet10 Twitter community. Rather, my intention was to observe, describe and characterize the nature and content of interactions, including looking for changes in “affinity identity” with the group or attempts to support other members of the community who were figuring out how to teach science to elementary students and implement NGSS.

Yin (2014) promoted case study design when the opportunity presents itself to look closely at a body of data that is rich with detail. He cautioned that one must remain adaptable and goes further to explain that a case study rarely ends up where it was first headed. In case study research, one must set out in a particular direction but allow the

data to determine where to probe further. This is especially true in the present research study. With a total of 671 tweets and retweets plus images, video, hyperlinks, hashtags, and mentions (see Chapter 1 for a definition of these terms), data points were somewhat unique and led my analysis in many different directions. I used a variety of ways to inspect and characterize data. Case study design gave me the flexibility to explore data in a variety of ways until I was satisfied that I had evidence for the theme of each tweet and retweet.

All research questions could have been addressed using a design of a single case study. Yet designating some individual users as sub-cases added another layer of data collection to help triangulate the coding data from tweets and retweets of the single case, meaning the entire community. Yin (2011) advised that designating subcases under a case may yield additional data that could be missed when compared to a single case study alone. This was the rationale for designating some users as subcases and compiling a user profile for each subcase. More details may be revealed through delineating subcases within the whole case study. Therefore, within this case study, users who responded to a follow-up survey I considered as subcases (Yin, 2011). Each of these subcases presented data that contributed to a user profile. I asked users to approve their user profile or edit it until the user was satisfied that the profile was valid. This provided an additional layer of data that was used to validate the coding procedure for each of the usernames designated as subcases.

Content analysis (Richards, 2015) allowed me to inspect text to characterize the intention of the tweeter. Once I established a theme, I confirmed the hypothetical theme of the text by further inspection of all other sections of the tweet or retweet, including

images, video, hyperlinks, hashtags, and mentions.

### **Context of the Parent Organization**

The parent organization from which the digital community of practicing teachers arose (“GEMS-Net”) has been independently operating for over two decades. One mission of this organization is to support K-8 teachers in teaching science. The organization has been described as a University-Districts Partnership on its web site. The parent organization is now guided by the Framework for K-12 Science Education (National Research Council, 2012) and aligns with Next Generation Science Standards (NGSS). The organization uses and supports a FOSS, kit-based science curriculum for the teaching of elementary school science.

The 2018-19 Teacher Database of the parent organization, GEMS-Net, revealed 653 teachers on their roll. Teachers listed on this database were affiliated with 11 school districts and one charter school. Approximately 11% of the teachers on this database were listed as followers of the digital community, @gemsnet10.

One of the missions of the parent organization of GEMS-Net is to provide ongoing PD for participating teachers of science. Teachers are offered two to five sessions of professional development per year (S. Sweetman, personal communication, Jan, 2017) in various locations around the State. Sessions can be of various lengths but all are centered around the implementation of Units from FOSS kits. All teachers who are in the GEMS-Net organization are required to attend at least one face-to-face PD session per year.

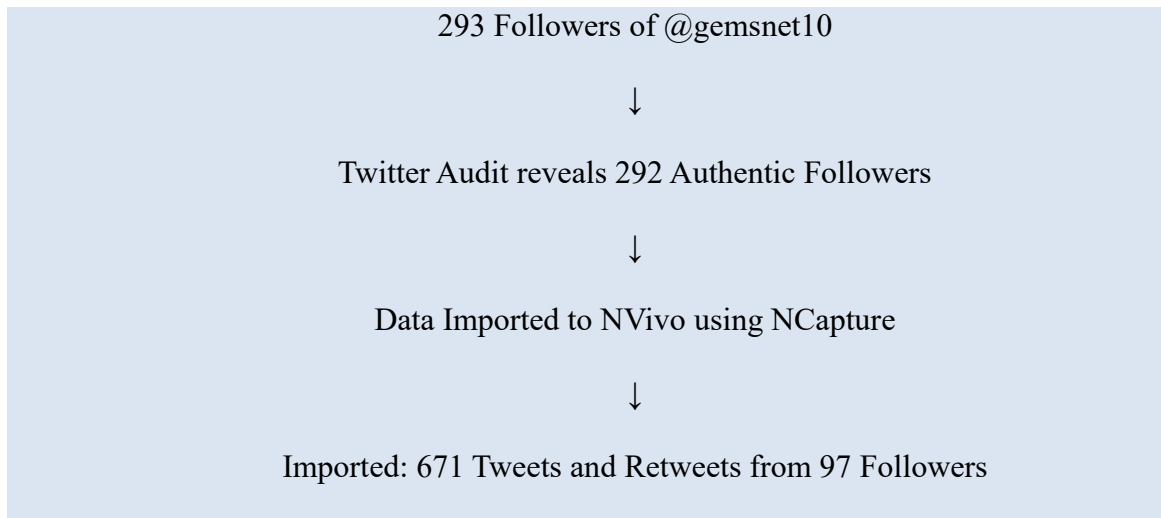
In January of 2014, “GEMS-Net” leadership initiated a public account on Twitter with the username @gemsnet10 and invited all members of GEMS-Net to join this digital

community. Participation in the Twitter feed community was and has always been completely voluntary. Administrators sometimes post to @gemsnet10 for various reasons such as sharing information about events.

## **Participants**

Participants for the single case study were all followers of @gemsnet10. The followers of @gemsnet10 have a Twitter account of their own and have clicked the “follow” button on the @gemsnet10 page. There were 293 followers of @gemsnet10 at the time of import by NVIVO of all tweets and retweets of @gemsnet10, and all but one account were characterized as “authentic” using an app called Twitteraudit.com. Ninety-nine percent of all followers were considered valid accounts.

It should be noted that at the time of data import by NVIVO, only 97 out of 292 authentic usernames were imported. There are several reasons for this. Some Twitter accounts are “protected,” meaning that the account holder needs to give permission for access, so these accounts were not automatically imported by NVIVO. In addition, many followers view other Twitter accounts and never tweet or retweet, so there would be no data to import for these users. This type of participation has been termed “lurking” and is considered a frequent practice of participants in social media. “Lurkers are followers that view tweets and retweets of another user but do not post a tweet or retweet. Estimates of “lurkers” are as high as 99% (Nonnecke & Preece, 2001) although the numbers suggest that the maximum possible percent for this community would have to be 68.2% or less. Also, “promotional tweets,” or ads, were not imported into NVIVO. See Figure 3.1.



**Figure 3.1.** Flowchart for data import to NVivo

### **Procedure**

The case for validity in qualitative research is built upon finding evidence from different sources to corroborate claims (Patton, 2002). In this research study, I collected data from more than one source. The primary data source was Twitter data imported via NCapture to NVivo (Bazeley & Jackson, 2013), backed up by content analysis (Fraenkel et al, 2012) of images, video, and hyperlinks. The secondary data source came from survey responses that I imported via NCapture to NVIVO.

**Twitter.** Twitter is a public microblogging platform that is free to access and use (Twitter Guide Book, 2018). Participants of Twitter, identified by “usernames,” communicate with others using up to 140 characters (at the time that the data was collected) as well as hyperlinks, images, and video. Users choose to write original posts (Tweet) to their “Followers” and/or individual users or share posts from those they “Follow” to their followers (Retweet). Users can target messages to groups interested in specific topics through the use of hashtags and they may also tag users in a post by

including a username of the person they are tagging. Users can be asynchronous or choose to “chat” at a predetermined time to exchange ideas on a common domain. Users can gather in a group by posting a hashtag. For the purposes of this study, users will be considered participants if they tweet, reply, retweet, or report that they observe the tweets of others.

Twitter accounts are generally public, and this includes the @gemsnet10 account. However, Twitter provides an option for users to “protect” their Tweets, meaning that a follower’s tweets will not be seen by a public viewer unless the follower is approved by the User. Of the 303 followers of @gemsnet10, 16 followers (5.2%) protected their tweets. These followers were omitted from the present research study.

**NVIVO.** I used QSR International’s NVIVO 14.4.2 (2018) for qualitative data analysis throughout my research study, both for original Twitter data and survey data. Data was imported to NVIVO as a “dataset” which allowed for further analysis and was stored in NVIVO in a spreadsheet format. Data from ninety seven usernames were imported to NVIVO, representing 671 tweets and retweets from January 1, 2014, to December 31, 2018.

Upon import, data was separated into several characteristics: (a) ID (number 1 represented the most recent tweet that was imported, number 2 represented the second most recent, etc.), (b) Tweet ID (a unique 19 digit number assigned by NVIVO to each tweet or retweet), (c) Username (Twitter handle), (d) the tweet or retweet itself, (e) the time and date stamp, (f) whether the data was a tweet (original post) or retweet (shared post from another user), (g) the username associated with the retweet if there was one, (h) how many times the tweet was retweeted, (i) the number of hashtags and what they were,

(j) the number of mentions of a user name, (k) the name and the location of the user, (l) a link to the user's website, (m) the user's bio, (n) the total number of tweets, (o) total number of followers of the user, and (p) the number of other users that the particular user is following, and (q) the digital coordinates of the tweet.

### **Step-by-Step Protocol**

Data were gathered in the following manner:

1. All tweets and retweets were imported by NVIVO as a "dataset" from January 1, 2014 to December 31, 2018. Import of data from Twitter to NVIVO was done via a Google Extension called NCapture. Data imported as a "data set" to NVIVO can be coded and recoded as themes of codes emerge and evolve. Codes remain assigned to data unless specifically removed by the researcher so the history of the evolution of codes can be tracked for each tweet or retweet in the collection. In total, 671 tweets and retweets were imported to NVIVO, each with a unique identification number that was permanently linked to a singular tweet or retweet. At the time of the data import, the Twitter community was following 245 other Twitter users. Two hundred ninety-two authentic Twitter users were following @gemsnet10 at the time of import.
2. Followers of @gemsnet10 were sorted by profession. If no profession was declared on each follower's home page, the follower was categorized as "undeclared." However, if "followers" of the Twitter community were undeclared regarding their profession, tweets and retweets from their home page were used to gain further evidence about profession. For example, if a

follower posted "My fourth grade class enjoyed..." then they were listed as a teacher, even though the profession of teacher was not explicitly stated on their Twitter profile. All other professions that were represented in the @gemsnet10 Twitter feed community were tallied as categorized by the individual "follower" on their Twitter home page profile.

3. I invited members of *both* GEMS-Net and @gemsnet10 to fill out a short survey on Google Forms. The survey was brief and had three overall purposes: (a) identifying information for each survey respondent including years in teaching practice and grades taught, (b) gathering evidence for the history of Twitter use and ease of proficiency with technology, and (c) asking individual users about the value of the Twitter community and the meaning of voluntary participation for each user. In a key survey question, I asked straightforwardly about the meaning of participation in the Twitter community and the value of this participation. Dillman, Smyth, and Christian (2014) suggested that surveys should be brief and accessible in several formats to maximize response rate. The survey was constructed using Google forms which could be administered on computer, tablet, or Smartphone formats. There were nine questions in both short-answer and Likert-style.

In all, 42 potential participants (i.e., 42 potential subcases) were sent a recruitment letter (see Appendix A) to ask them if they would be willing to participate in my study by filling out a short survey. The recruitment letter was sent to all eligible participants by placing email addresses in the Blind Copy (BCC) section of the address line for privacy of potential participants.



Originally, 35 emails were sent out, with an additional 7 added to the list when additional email addresses were obtained. If a potential participant read the information on the recruitment letter sent by email, they were asked to click on a link at the end of the letter to be directed to the consent form (see Appendix B). If accepting the terms of the consent letter, participants were asked to click on a link that would lead them to a brief survey (9 questions) about their participation in the Twitter Feed Community (see Appendix C). Six reminder emails were sent after the first email, approximately one per week. Twelve participants completed the survey.

4. All survey responses were imported by NVIVO as a “dataset.” I imported data from individual users’ responses to a survey as a “dataset” to a separate file in NVIVO. I obtained email addresses from GEMS-Net databases of professional emails.

### **Data Analysis**

I characterized tweets and retweets from a five-year period by sorting for theme. I looked for willingness to share information or resources that one community member presumably anticipated was valuable to other community members, including information about pedagogical, content, and pedagogical content method. I searched for evidence of SEPs, CCCs, and DCIs as outlined by the Framework for Science Education (NRC, 2012). I inspected text as well as images, videos, and hyperlinks to determine if the intention of the tweeter may have been to show an affinity with other community members by way of acknowledging others’ work to showcase shared values. If data showed that community members retweeted others’ ideas then an underlying assumption

could be that the substance of the tweet was considered valuable to the re-tweeter as well as presumed to be valuable to other community members. If members of the Twitter feed community shared pedagogical knowledge, content knowledge, or pedagogical content knowledge (as previously defined in Chapter 1), the underlying assumption was that other community members would find such shared methods useful or in some way valuable to their own practice. If community members tweeted references to NGSS by sharing common language, practices or concepts as outlined by the Framework for Science Education (2012) then an underlying assumption could be that at least some members of the Twitter feed community were collaborating to support implementation of NGSS.

I used autocoding, a function of NVIVO, to separate each column of the Twitter dataset into “nodes” or digital “buckets” that could be retrieved and further analyzed. Two types of autocoding, word frequency queries and text searches, were used to get a sense of general themes of digital interactions. Next, I performed text searches using NVIVO based on keywords (see Appendix D) associated with the three dimensions of NGSS: (a) science and engineering practices, (b) cross-cutting concepts, and (c) disciplinary core ideas (NGSS Lead States, 2013). This procedure was abandoned after determining that (a) there were relatively few correlations between keywords of a dimension of NGSS and the text, and (b) even though some correlations were found, there were relatively few instances where the intention of the tweet matched the category of the keyword. For example, if “observe” was a keyword on the SEP chart, in some cases the word “observe” could be found in the dataset of tweets. However, the researcher did not conclude that “observe” was used as defined by NGSS, so could not be

assigned the corresponding code. Ultimately, this process was abandoned as unfruitful to data analysis and codes were assigned by reading tweets in reverse chronological order and assigned codes in the same order.

I then performed manual assignment of codes in NVIVO to characterize the themes of teachers' digital interactions in the form of tweets and retweets interactions. Richards (2015) outlined the coding procedure for this study. I read tweets and retweets (which were estimated at approximately 15 double-spaced pages of text) three times to get a sense of the themes of participants' responses before coding began. I took notes during this process about the possibility of general themes, however no codes were assigned at this point in the process. After reading all tweets and retweets three times, I began the process of practicing coding themes to each tweet and retweet. Some tweets and retweets were coded for two different themes. Others had parts of the tweet or retweet coded with a theme and another part coded with another theme. Codes were attached to tweets and retweets digitally through NVIVO and the code remained attached unless detached deliberately by the researcher.

After I was satisfied that themes were beginning to emerge, a reliable round of coding began. Using NVIVO, parts of the text (tweets, retweets, or survey answers) were highlighted and a memo box appeared which allowed the researcher to name a code to reflect the theme. In addition, a description of the code to the code name for future reference. If there was a question about the theme of the text, I used images, hyperlinks, and/ or video to clarify the theme of the text in question. I copied and pasted a tweet or retweet was too long to be imported in its entirety to the search box of the [Twitter.com](https://twitter.com) website. This search brought me directly to the complete tweet so a coding determination

could be made.

This process was repeated with codes being assigned, reassigned, or split in further categories until I reviewed all codes and was satisfied that each code adequately reflected the theme of the text. It should be noted that using NVIVO software, code history remained intact with each section of the text even if codes were changed. Hence, the progression of the codes was reliably retrievable all along this process unless a tweet or retweet was “uncoded” by me, meaning that I no longer felt that the code was appropriate to the text, and used NVIVO to disconnect the link between text and code.

Patterns and frequency of final codes are described in Chapters 4 and 5 with accompanying results of the community as a whole as well as individual data related to user profiles. Only four tweets or retweets were not codable. In each of these cases, either the text was uninterpretable by the researcher or the link was no longer live, so a determination of the theme of the code was impossible.

To address the second research question and uncover patterns of interactions among teachers to reveal trends in themes of codes, matrix queries were used to characterize frequency of codes over time. I exported matrix query results to an Excel spreadsheet as a tab-delimited text file, or .txt, to be further analyzed through graphing on Excel.

### **Content Validity**

Validity of qualitative research was established by comparing data over several sources: (a) reading and coding tweets and retweets from the Twitter community to construct a community profile, (b) survey results from responses from each user to assess the meaning of participation in the community, (c) approval and/or edit of each user

profile by the user as constructed by the researcher to characterize the precise nature of the meaning of participation in for all users who submitted survey results.

**Institutional review board.** Forty-two participants were identified as practicing teachers, members of GEMS-Net, and followers of @gemsnet10 with working emails from the GEMS-Net database. Teachers were contacted through their professional emails. Periodic reminders were sent using the same method. The email contained a Recruitment Letter (see Appendix A) that was approved by the Institutional Review Board (IRB) at the university at which the researcher was affiliated. At the end of the Recruitment Letter, a hyperlink led to a Consent Form, also approved by the IRB (see Appendix B). After agreeing to the terms of the Consent Letter, the participant was asked to click on a hyperlink that connected the participant to the survey on Google Forms. See Appendix C for a list of survey questions. Responses of the participant to the survey were automatically loaded onto a Google Sheets spreadsheet that was accessible only to the researcher.

Description of how user profiles and community profile were constructed. In an effort to maintain robust research procedures as well as to reach valid conclusions for this relatively small and unique population, there were several steps toward the goal of constructing both community and user profiles.

I constructed user profiles using the following procedure: (a) tweets and retweets were assigned codes using the entire five-year history of imported tweets and retweets (n=671). I separated users and gathered the history of each user's tweets and retweets was using NVIVO software. Also, I examined each user's tweets and retweets for patterns in frequency and type of codes over time.

I gathered survey results for each user and codes were noted for short answer questions concerning why the user participated in the voluntary Twitter community. A user profile was constructed by me to describe the user's coded texts and frequency of coding.

Survey answers were examined for each user to validate the user profile. The user profile was offered to the user for editing or approval until the user was satisfied that the profile validly described the user's experience as a voluntary participant in Twitter community. By contrast, the community profile was constructed by describing patterns in coding of tweets and retweets. In addition, text searches and word frequency search data were used to help describe the type and frequency of interactions of the voluntary participants of the @gemsnet10 Twitter community as a whole.

### **Member-checking**

I identified individual users as @usernameX, with X represented by the number on the Google spreadsheet that corresponded to the Google Forms survey responses.

When asked to read, approve, or edit their Twitter user profile, Twitter users were emailed directly by the researcher. Twitter users replied directly back to the researcher. Any further communication between users and researcher were not shared. When Twitter users approved their profiles, email communication was saved on a password protected laptop and accessible only to the researcher (and by request, the Twitter user).

**Inter-rater reliability.** I assessed reliability of coding of tweets and retweets by randomly choosing 20 tweets or retweets by unique identification number assigned by NVIVO. An independent coder assigned codes based on the same definitions as those used by the researcher. If agreement did not reach a generally acceptable 85% or greater

then a discussion ensued to reach agreement between me and the independent coder until agreement was reached. This procedure was repeated until the 85% criteria of agreement was reached. After 10 examples, agreement between the independent rater and myself approached criteria. I concluded that, using code definitions as a framework, the independent rater could reliably match my coding themes. Discussion resolved all discrepancies.

### **Summary of Chapter 3**

Chapter 3 gave the rationale for choice of methodology. I chose a mixed methods approach known as a convergent parallel mixed methods design. Quantitative data was used to augment qualitative data as a way of further characterizing the entire Twitter feed community by showing trends in codes over time.

The qualitative part of this mixed methods design was framed as a case study with the case defined as the entire Twitter feed community. I defined subcases by their de-identified user names. Content analysis (Fraenkel et al., 2012) was used to formulate the intention of the tweets. Survey responses were used to validate assigned codes that had been matched with tweets or retweets about the value of the Twitter feed community for participants. User profiles were constructed and I used member-checking until I was satisfied that their profiles were accurate representations of users' reports of the value of participation in the Twitter feed community.

## CHAPTER 4

### FINDINGS: COMMUNITY PROFILE

#### **Introduction to Chapter 4**

In Chapter 4, I analyzed and summarized descriptions and characteristics of the Twitter feed community as a whole so that I could characterize the context for the digital interactions of members within this community as an attempt to answer both research questions: (a) what do reform-minded practicing teachers talk about in a Twitter feed community, and (b) are there patterns of participation for members of this community that suggest changes in affinity identity or reform-minded pedagogy?

#### **Findings of the Community as a Whole**

At the time of data import to NVIVO (June 19, 2019), analysis of the Twitter feed community revealed a total of 292 authentic “followers” of @gemsnet10. All except one “follower” of @gemsnet10 was confirmed as having authentic Twitter accounts by Twitteraudit.com, a free application to sort authentic versus “fake” Twitter accounts. Twitteraudit found only one “fake” account. Consequently, the audit rate for legitimate accounts was 99% for the @gemsnet10 organization. Furthermore, Twitter statistics showed that this organization “followed” 245 other Twitter accounts (users).

**Duration of Twitter accounts.** Data regarding number of months that each follower “followed” @gemsnet10 could have been estimated by examining their home page for the first indication of a reference to the GEMS-Net community, but this number may not have significant meaning considering that followers had unlimited access to the Twitter feed community even if not actually “following” @gemsnet10. In other words,



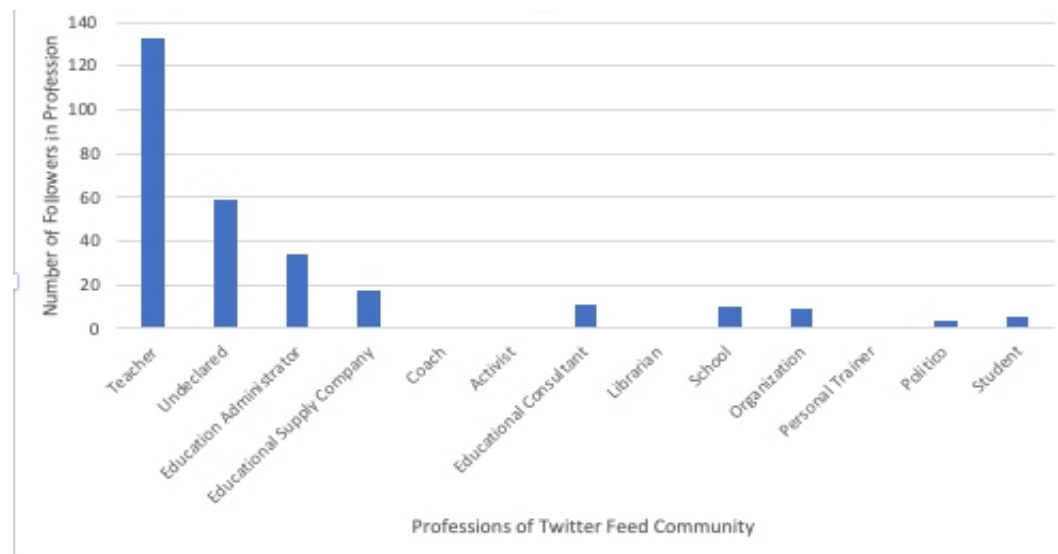
pre-followers could have viewed the interactions of the @gemsnet10 community simply by searching via the @gemsnet10 username from the Twitter search box since the account is public. The only prerequisite to this process would be that a viewer have a Twitter account, and therefore, a home page of their own. However, in the interest of divulging general descriptors of followers of @gemsnet10, the average number of months that each follower was a member of Twitter was calculated. This number could give some indication of each follower's experience with Twitter in general, but again, did not reveal how many months each follower "followed"@gemsnet10.

### **Professions of Followers**

Most followers of @gemsnet10 stated their profession in their Twitter profile. If the profession of a follower was not explicitly stated in their profile, I examined tweets on the home page or evidence of a stated profession. For example, if a tweet contained a phrase such as "my fourth grade students," I categorized the follower as a teacher. In this way, 293 followers were definitively categorized by profession.

A breakdown of followers' professions revealed these percentages, in descending order (see Figure 4.1): Teachers (46.5%), Undeclared (20.6%), Educational Administrators (11.9%), Educational Companies (5.9%), Educational Consultants (3.8%), Schools and Community Organizations (each 3.1%), Students (1.7%), Politicos (1.4%). Four other minor categories, including Coach, Educational Activist, Librarian, and Personal Trainer, each represented 0.3%. The Undeclared category included four user accounts that were "protected." For protected accounts, one must request and be granted access by the user before account information is revealed. Therefore, no "protected" accounts were included in the data since the researcher did not have access to these

accounts (see Figure 4.1).

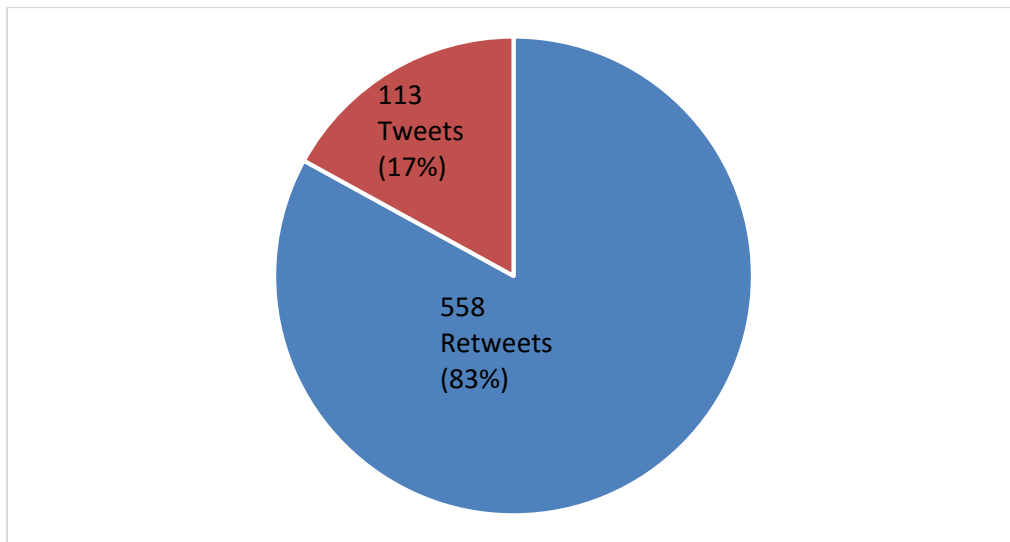


*Figure 4.1.* Breakdown of Twitter feed community by profession

**Tweet/retweet results.** As stated previously, I collected tweets and retweets for a five-year span on June 19, 2019. In addition, profiles of all members in this community were characterized by me after consulting home profiles of each member listed as a “follower” of @gemsnet10 to determine various characteristics of the community.

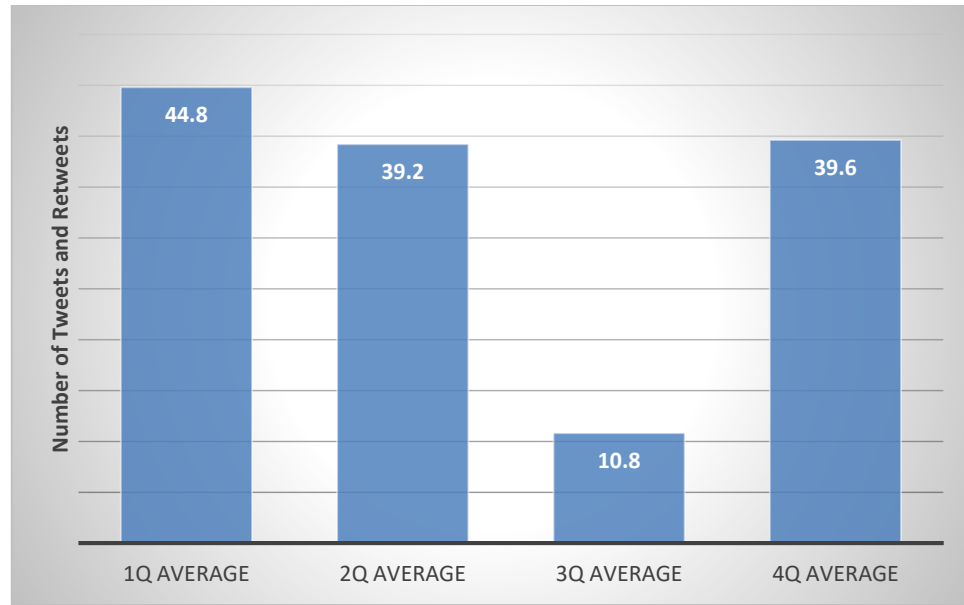
Of the 671 total tweets and retweets that were imported by NCapture into NVIVO as a data set, 558 (83%) were retweets and 113 (17%) were tweets (see Figure 4.2). Both tweets and retweets were considered by the researcher as equivalent when coded. The rationale behind this decision was as follows. By definition, tweets were original thoughts from the tweeter, and retweets were shared tweets of others. However, the intention of the user’s message was essentially considered the same in both types of posts. The Union Metrics Blog (Parker, 2016) advised that retweets are useful when sharing a message that is considered valuable and for which the user has nothing to add

[emphasis added]. Both tweeting and retweeting shared an idea or set of ideas deemed valuable by the user for other followers.



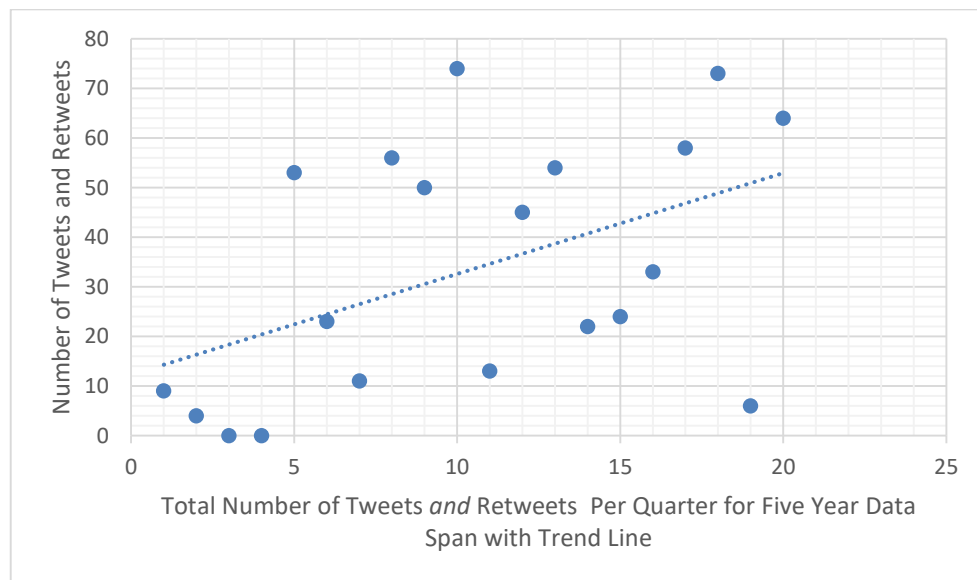
*Figure 4.2.* Percentage of tweets and retweets for the entire data set.

When the total number of tweets and retweets were tallied per quarter, a marked trend was revealed. The frequency of tweeting and retweeting decreased in the third quarter of every calendar year when quarters were averaged over five years (July, August, and September) (see Figure 4.3). This information shows evidence that this Twitter feed community is closely affiliated with the rhythm of the school year, tweeting and retweeting least frequently during the summer months and the beginning of the school year, the former when educational professionals are least likely to be in the classroom, and the latter when teachers and administrators are most likely to be occupied with establishing routines and cultural norms in the classroom and may not have as much time to connect with colleagues in their digital community.



*Figure 4.3.* Average number of tweets and retweets over five years of data per quarter of calendar year

Overall, even though this Twitter feed community has always been voluntary for participants, the general trend of number of tweets and retweets has gradually increased over time (see Figure 4.4).



*Figure 4.4.* Total number of tweets and retweets combined per quarter over five year

**Hashtags and mentions.** Hashtags and mentions were not investigated in this research study except to further characterize the nature of interactions within @gemsnet10. Within the structure of tweets and retweets, followers used hashtags and mentions to make connections to other Twitter users.

Hashtags were used before a word or phrase to gather tweets and retweets about a certain topic to a common digital “space.” For example, within a tweet, if the phrase #sciencedata was included in the body of the tweet (or retweet), it would be accessible in a common digital space along with other tweets and retweets marked with the same hashtag, #sciencedata. In this research study, hashtags were used 160 times (see Figure 4.6) and were contained in 23.9% of tweets and retweets.

Mentions were also used to direct a tweet or retweet to another user’s timeline by listing the username within the tweet or retweet (Twitter Guide Book, 2018). For example, if a username such as @RelevantScience were posted within a tweet or retweet, the tweet or retweet containing the mention would be posted in the original user’s account as well as the timeline of @RelevantScience. Mentions were used 147 times and were contained in 22% of tweets and retweets.

**Word frequency.** When I conducted a word frequency query via NVIVO for the entire Twitter dataset, the most frequent “word” was https (n=414) followed by @gemsnet10 (n=356). This indicates that some tweeters were intentional about using hyperlinks to lead other community members to additional information to augment their tweet or retweet. Htps was included at the start of hyperlinks that connected images, video, or resources to the tweet or retweet. Moreover, the mention of @gemsnet10 was an intentional effort to post a follower’s tweet or retweet on the home page where the

digital community was based. This action also highlights an intention to connect to the homepage of the community.

Other words in the top ten most frequent list include various forms of the word “science” (n=135), “learning” (n= 98), “students” (n= 79), and “teachers” (n= 53). The balance of top ten most frequent words were usernames that were frequently mentioned within tweets or retweets.

**Description of codes.** I used codes to characterize themes of interactions among the followers of @gemsnet10. Remarkably, when reading through the 671 tweets and retweets, it was noted that all but one of the interactions could be classified as professional rather than personal in nature. Themes revolved around science and literacy, teaching, classrooms, curriculum, students, acknowledgement of valuable work in self and others, and professional events which were sponsored or endorsed by the parent organization or other educational organizations.

In the one case where the tweet could be classified as personal, a follower was attending a professional event hosted by the parent organization, but posted a picture of her child participating in the event. So, even in this single case, the tweet was partially related partially related to the follower’s profession. Hence, the researcher considered this Twitter feed community as professional in nature partly based on themes of its interactions.

As stated in Methods, coding of data for this research study was a continually dynamic process of defining and redefining themes. It is estimated that a minimum of three passes through the dataset of 671 tweets and retweets was necessary to solidify a reliable assignment of themes that the researcher felt remained consistent throughout all

of the data for the entire community.

Many codes were closely associated with other codes. However, the goal of the coding process was to assign the most closely associated code to a tweet or retweet. Sometimes, sections of text had a primary theme that matched one code while another section of text in the same tweet or retweet matched another code. Several times, the same section of text reflected two themes equally, so both codes were assigned to the same text.

Notably, Chapter 5 will recount that for survey data collected from individual users of the F2F group used to validate individual user profiles constructed from the Twitter dataset, additional codes were assigned to reflect new themes that emerged. For the entire list of codes and their descriptions, see Figure 4.6.

Coding results for reform (NGSS) codes. Four codes emerged related to NGSS. This group was designated as reform codes. For code names, descriptions, and definitions, see Figure 4.5.

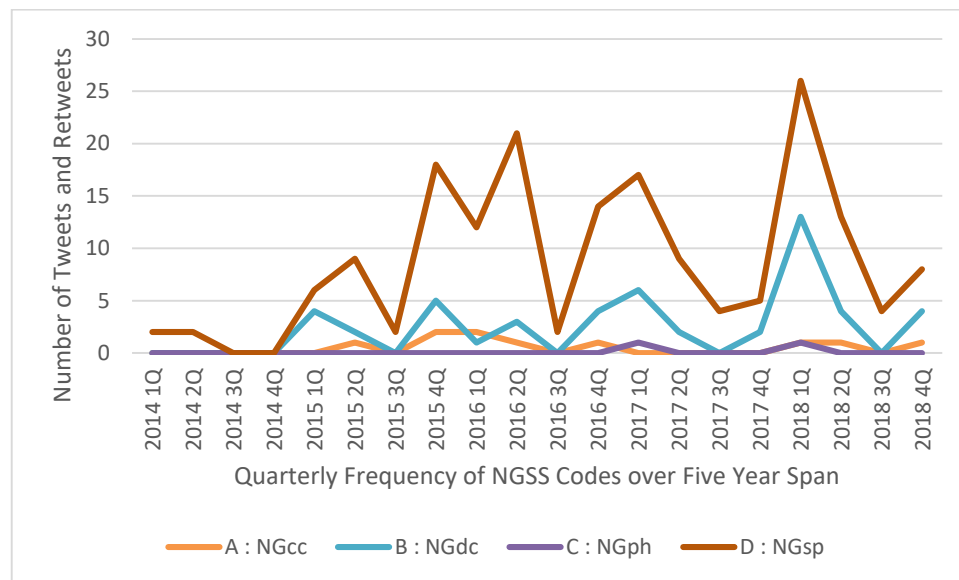
Code Name	Code Description	Code Definition
NGsp: NGSS Science and Engineering Practices	Evidence of NGSS Science and Engineering Practices as stated in the Framework for K-12 Science Education	Asking questions and defining problems Developing and using models Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations and designing solutions Engaging in argument from evidence Obtaining, evaluating, and communicating information
NGdc: NGSS Disciplinary Core Ideas	Evidence of NGSS Disciplinary Core Ideas in Physical, Life, and Earth & Space Sciences as stated in the Framework for K-12 Science Education	Topics directly related to NGSS disciplinary core ideas K-8 (nextgenscience.org)
NGcc: NGSS Crosscutting Concepts	Evidence of NGSS Crosscutting concepts as stated in the Framework for K-12 Science Education	Patterns Cause and Effect Scale, Proportion, and Quantity Systems and System Models Energy and Matter Structure and Function Stability and Change
NGph: NGSS Phenomenon	Evidence of using an observable phenomenon to engage students in science learning	Explicit description or reference of phenomenon

*Figure 4.5.* Reform (NGSS) codes

For reform codes related to NGSS, results indicated that the NGsp (Science and Engineering Practices) code was most frequently assigned. Even as early as the first



quarter, the Twitter feed community displayed and discussed science and engineering practices, as defined by the Framework of K-12 Science Education (NRC, 2012). Four peaks were noted in the frequency of this code: (a) the fourth quarter of 2015, (b) the second quarter of 2016, (c) the first quarter of 2017, and (d) the first quarter of 2018 (see Figure 4.6). Relative levels of NGSS codes revealed that NGsp codes dominated as compared to other NGSS codes throughout the five year data set.



*Figure 4.6. Quarterly frequency of reform (NGSS) codes over time.*

The second most frequently assigned NGSS code was NGdc. This code was assigned when tweets and retweets discussed or showed evidence of discussion about disciplinary core ideas of NGSS, as defined by the Framework of K-12 Science Education (NRC, 2012). Disciplinary core ideas are the main science concepts, sometimes referred to as science content. Peaks for NGdc were noted in (a) the first and fourth quarters of 2015, (b) the first quarter of 2017, and (c) the first quarter of 2018.

The third most frequent reform code related to NGSS was NGcc, with one peak

noted in the fourth quarter of 2015. This code referred to crosscutting concepts as defined by the Framework for K-12 Science Education (NRC, 2012). Crosscutting concepts are ideas that are present across science disciplines, such as Cause and Effect, or Patterns.

There were only two explicit mentions of phenomenon, coded as NGph. The Framework for K-12 Science Education (NRC, 2012) defined a phenomenon as a natural event that is observable and will entice students to become engaged in the science process with the ultimate goal of increasing understanding of disciplinary core ideas, or DCIs. Phenomena are often used in NGSS to launch units. Students are asked to observe a phenomenon and explain how and why the phenomenon occurs. With teacher as facilitator, students' efforts to increase understanding of a DCI are based on activities they design to answer the "how" and "why." In the body of Twitter data, the explicit mention of phenomenon occurred once in the first quarter of 2017 and once in the first quarter of 2018 (see Figure 4.7). It was difficult to code for phenomenon when an explicit mention was not made in the tweet. This may not adequately represent the actual number of references to phenomenon. This limitation of the experimental design will be discussed further in Chapter 6.

Codes results for science teacher knowledge codes (STK). Codes regarding science teacher knowledge and their descriptions and definitions are represented in Figure 4.7. These codes are based on terminology coined by Schulman (1986) about types of teacher knowledge. Terms have been adapted for science teacher knowledge. Pedagogical knowledge refers to methodology of teaching. Content knowledge refers to knowledge of content information. Pedagogical content knowledge refers to knowledge of

methods that are specifically used to teach specific content.

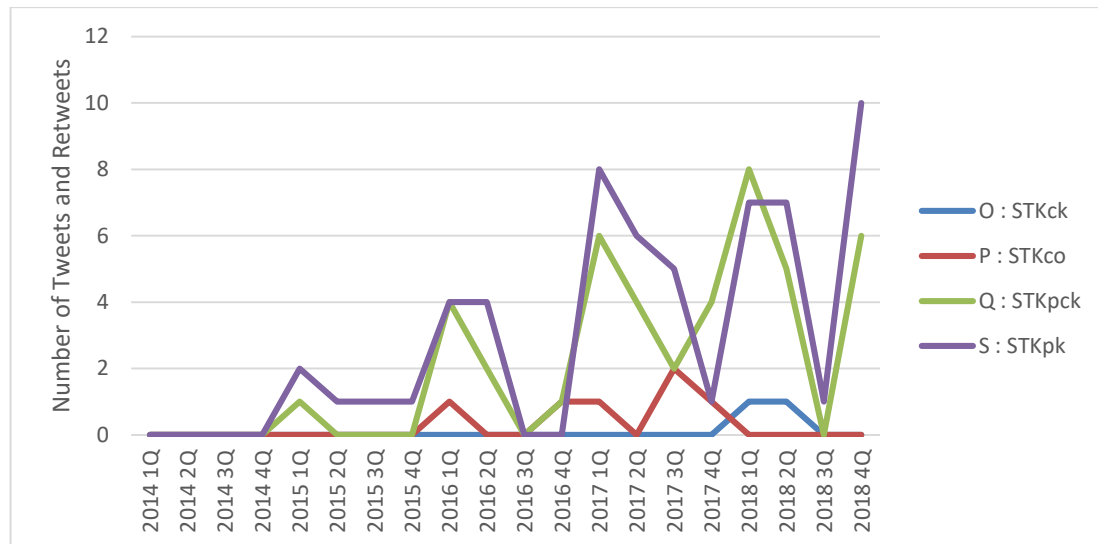
Code Name	Code Description	Code Definition
STKpk: Science Teacher Knowledge-pedagogical knowledge	Discussing Pedagogical Knowledge	General knowledge of pedagogical techniques not specifically related to science
STKck: Science Teacher Knowledge-content knowledge	Discussing Content Knowledge	Knowledge of science content
STKpck: Science Teacher Knowledge-pedagogical content knowledge	Discussing Pedagogical Content Knowledge	Knowledge of pedagogy that relates to specific science content
STKco: Science Teacher Knowledge-collaboration	Inviting collaboration with others	Suggestion or offer to work with another teacher or group in pursuit of science learning
STKpd: Science Teacher Knowledge-professional development	Discussing Professional Development	Learning from other teachers and groups of teachers

*Figure 4.7. Science teacher knowledge (STK) codes*

For most of the first year, there were no codes showing evidence of content knowledge (STKck), collaboration with others (STKco), pedagogical content knowledge (STKpck), or pedagogical knowledge (STKpk). In the subsequent four years, pedagogical knowledge was most frequently coded, with peaks noted in (a) the first quarter of 2015, (b) the first and second quarters of 2016, (c) the first quarter of 2017, and (d) the first, second, and fourth quarters of (see Figure 4.8).

Figure 4.8 also shows that STKpk and STKpck codes were generally more frequently assigned over time. Notably, the STKco code, which is described as a “suggestion or offer to work with another teacher or group in pursuit of science learning,” had a relatively steady but low level of frequency of occurrence.

In contrast, STKck, or content knowledge was not assigned until the first and second quarter of 2018, which was the fifth year of the Twitter feed community.



*Figure 4.8.* Quarterly frequency of science teacher knowledge (STK) codes over time

Coding results for science teacher affinity identity. The STAI codes were named for Gee's (2000) construct of affinity identity, whereby individuals gain power through association with a group. There were seven STAI codes (see Figure 4.9 for definitions and descriptions) for Twitter data, and three additional affinity codes related to survey data. The first seven codes in Figure 4.11 below will be discussed in the present chapter and the last three codes (STAIsg, STAIsf, STAIpc) will be incorporated into User profiles in Chapter 5.

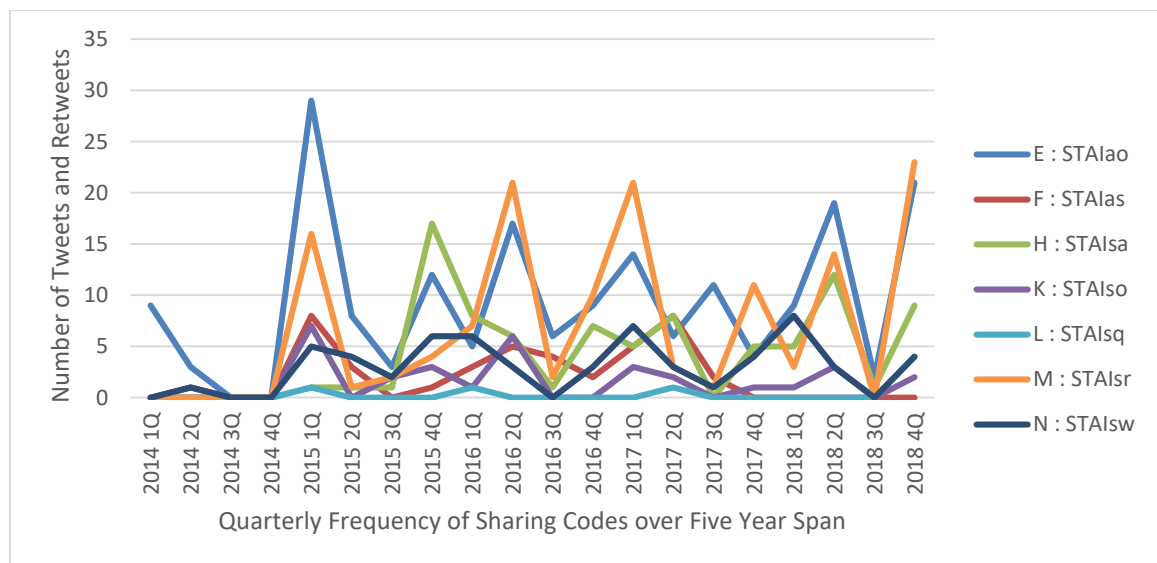
Code Name	Code Description	Code Definition
STAIas: Acknowledge self	I did this work and it is valuable	Share your own work with others that community may value
STAIao: Acknowledge Others	You did this work and it is valuable	Share your validation of the valuable work of others
STAIsr: Share Resources	Sharing curriculum, opportunities, events that other teachers would value	Share valuable resources of any type that is useful to community members
STAIsw: Student Work	Calling attention to exemplary or valuable student work	Share exemplary work of your students or other students with community members
STAIsa: Share Activities	This is what we did today in class or in an informal class setting	Share information about students' activities in your classroom
STAIsq: Share Questions	Does anyone know about...? How to...?	Share your question expecting that your knowledgeable community will provide an answer
STAIso: Share Opinion	I think that...	Share your opinion about science-related or other topics with your community
STAIsg: Mentions GEMS-Net	Connection to GEMS-Net	Share willingness to stay connected to GEMS-Net
STAIsf: Mentions learning more about FOSS kits	Mentions FOSS kits	Share or ask how FOSS is used in your classroom
STAIpc: Mentions connecting with others in teaching profession	Professional contact	Sharing professional contact information among community members

*Figure 4.9. Science teacher affinity identity (STAI) sharing codes*

Three affinity codes (STAIao, STAIsr, STAIsa) were most prominently assigned. Interestingly, STAIao (acknowledging others) peaked very early (in the first quarter of 2015) and also peaked several times throughout the five-year span of data. The largest and second largest peaks happened in the first quarter of 2015 and the last quarter of

2018, respectively. In addition, there were several major peaks throughout: (a) fourth quarter of 2015, (b) second quarter of 2016, and (c) first and third quarter of 2017.

The STAI<sub>sr</sub> codes, sharing resources, was prominently assigned in all but the first, third and fourth quarters of 2014. Notably, peaks for STAI<sub>sr</sub> mirrored STAI<sub>ao</sub> in all but the fourth quarter of 2015 (see Figure 4.10). The third most frequent code in this group, STAI<sub>sa</sub> (sharing activities), peaked in the fourth quarter of 2015 and the second quarter of 2018. Sharing student work, STAI<sub>sw</sub>, was coded in all but four quarters, three of which were in 2014 and the last in the third quarter of 2018. The three least frequently assigned codes in this group were acknowledging self (STAI<sub>as</sub>), sharing opinions (STAI<sub>so</sub>) and sharing questions (STAI<sub>sq</sub>) (see Figure 4.12).



*Figure 4.10. Quarterly Frequency of Science Teacher Affinity Identity (STAI) sharing codes over time*

For a summary of all codes, the number of references for each code, and a percent coverage of the code as related to the entire text of tweets and retweets, see Figure 4.11. Coverage is a term used by NVIVO to describe the size of a tweet or retweet related to

the entire data set. A summary of % coverage ranked from most to least will be presented in Figure 4.14.

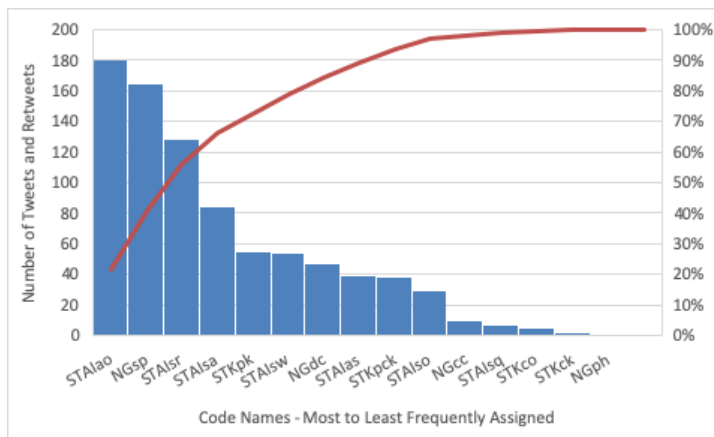
Code	References	%Coverage
NGsp	165	10.86
NGcc	10	0.57
NGdc	47	3.05
NGph	2	0.03
STAIao	180	15.24
STAIas	39	3.22
STAIsa	84	4.74
STAIso	29	2.51
STAIsq	7	0.58
STAIsr	128	10.41
STAIsw	54	2.54
STKck	2	0.21
STKco	5	0.43
STKpck	38	3.0
STKpk	55	2.78

*Figure 4.11.* Number of references and percent coverage of all codes of Twitter data

Codes were ranked from highest to lowest frequency over the five year time span (see Figure 4.12). The most frequent code overall was STAIao, which was about

acknowledging others. This code was assigned from the first quarter of 2014 and was predominant throughout the five year span of data.

The next most prevalent code overall was NGsp, a reform code about NGSS science and engineering practices, followed by STAlsr, defined as “sharing resources.”



*Figure 4.12.* Codes from Most Frequent to Least Frequent

## Summary of Chapter 4

Of the 293 followers of @gemsnet10, nearly half (46%) were teachers. The community also included a variety of other education-related professions, with some community members’ professions as undeclared. When teachers were divided into F2F versus NON-F2f groups, there was no significant difference in number of months on Twitter.

The Twitter feed community was professional in nature, and generally showed an increase in followers over five years even though participation had always been voluntary. Frequency of tweets was cyclical in nature, with the third quarter of each year



showing a drop in frequency of tweets and retweets, consistent with the calendar of the typical school year.

Coding results for the entire dataset of the Twitter feed community were summarized. Three codes were most prominent, representing 36.51% of coverage in total. The most prominent code was STAIao, acknowledging others, followed by the NGSS code representing science and engineering practices, NGsp. The third most prominent code overall (STAIsr) involved sharing of resources.

## CHAPTER 5

### FINDINGS: USER PROFILES

#### **Introduction to Chapter 5**

In Chapter 5, I analyzed data from a distinct sub-group of participants, members of *both* GEMS-Net *and* @gemsnet10 who volunteered to complete a brief survey (see Appendix C). My survey was based on a previous survey from Carpenter (2015). The survey asked about teaching experience, Twitter experience, and using Twitter for professional knowledge related to teaching. I added one specific open-ended question about the value of participation in @gemsnet10. I constructed a profile for each survey responder, de-identified as Users 1-12 rather than by their username from Twitter. I invited all survey respondents to edit and approve their user profile, a process known as member checking (Patton, 2002).

In this chapter, I summarized survey results related to each question. Next, I gave a breakdown of results for each individual survey respondent in a user profile for each user. The individual profile was constructed and kept intact so survey respondents could be asked to approve or edit their file for accuracy, a process known as member-checking (Patton, 2002).

Research questions asked (a) what do reform-minded practicing teachers “talk” about in a Twitter feed community, and (b) are there patterns of participation for members of this community that suggest changes in affinity identity or reform-minded pedagogy? Even though there were 133 confirmed teachers who were followers of @gemsnet10, 69 teachers who were *also* listed on the teacher database of GEMS-Net, the

parent organization for the Twitter feed community, were included in the survey because (a) these teachers were unique in that they belonged to both the Twitter feed community as well as the face-to-face community for professional development (both GEMS-Net and @gemsnet10), and (b) these teachers were accessible for administration of the survey that was used to triangulate themes in coding for the primary data set of tweets and retweets. In addition, contact information was available from the GEMS-Net database so that I could use member-checking to be sure that profiles that were constructed from twitter and survey data were accurate from the point of view of each survey respondent.

Twelve participants responded to the survey (29% response rate). According to Dillman, Smyth, & Christian, (2014), a valid survey response rate would be a minimum of 33%. This goal was not reached in spite of the fact that I sent four email requests and two in-person requests. In-person requests took place at two GEMS-Net teacher-leader meetings.

However, since the survey data were being used to triangulate the themes of the primary data set of tweets and retweets, and not analyzed as quantitative data per se, survey responses from the twelve survey participants were still used to construct user profiles as well as to compare to coding themes as another data source to triangulate findings from Twitter data (see Appendix C for survey questions).

In the following section, I summarized responses under each respective survey question. However, I still identified results for individual users.

### **Summary of Survey Results for each Survey Question for Users 1-12**

Teachers who responded to the survey reported that they were experienced teachers. Years of teaching experience ranged from 7-30 years with an average of 17.75

years of experience. All but three cases, survey respondents taught more than one grade during their professional careers. Seven survey respondents taught middle school. Seven had experience with K-2. Eight survey respondents had experience teaching Grades 3-5.

Respondents were asked to rate themselves on proficiency with technology, in general. All but one reported average or better proficiency with technology. Specifically, only one self-rated as “well below average.” Four reported “average” proficiency with technology, two self-rated as “slightly above average,” and five “above average.”

In response to the question, “Did you have a Twitter account prior to participation in the @gemsnet10 Twitter community?” five survey respondents reported joining Twitter for the purpose of following @gemsnet10. Seven respondents reported having a Twitter account for some time before “following” @gemsnet10. Specifically, half reported two years or less experience using Twitter before joining @gemsnet10. However, three reported 4 years or greater experience on Twitter before “following” @gemsnet10. When asked how often they viewed @gemsnet10 per week without tweeting or retweeting, four respondents reported 0-1 time per week, seven respondents reported 1-2 times per week, and one respondent reported 2-4 times per week.

I constructed user profiles by examining type and frequency of codes for each user from the main data set of tweets and retweets and comparing these codes to the codes of the response to the following survey question, “Why do you choose to participate in the Twitter community? You may have more than one answer to this question. Please list all reasons. Please be as detailed as possible.” The results of this comparison will be listed under the sub-sections below, labeled User 1-User 12. Exceptions to this procedure occurred when the construction of user profiles was

hampered by inaccessible information for Users 1, 4, and 11. In each case, the survey data could not be validated because of missing information about the user or the user's tweets. Other information about Users 1, 4, and 11 were provided if available. As previously stated, the term "coverage" represents the amount of text posted by a user compared to the amount of all texts posted by all users. For each user, their profile was constructed so that it matched the order of response to survey questions 1-9 for ease of making specific comparisons across users. In addition, I added information about the User's participation in @gemsnet10. I used survey responses to triangulate coding data from tweets and retweets.

### **Individual User Profiles**

In this section, I compiled individual user profiles. These profiles were shared with each de-identified user for approval or editing. I included all available data from the survey for all users, and triangulated the results of the open-ended question "Why do you choose to participate in the @gemsnet10 Twitter Feed community?" with coded tweets and retweets from @gemsnet10.

**User 1** reported use of Twitter related to teaching for 0-1 years, and "above average" proficiency with technology. User 1 also reported frequency of viewing @gemsnet10 without tweeting as 0-1 times per week. No other information was available for User 1.

**User 2.** User 2 reported use of Twitter for teaching for the past 1-2 years. From survey data, User 2 reported an "average" proficiency with technology. User 2 also reported viewing of @gemsnet10 without tweeting 0-1 times per week.

User 2 reported that participation in the Twitter feed was a valuable way to share

students' work and view the work of other students. Of the 17 references coded for User 2 from Twitter data exported from @gemsnet10 (2.53% total coverage of imported data), six reflected student work to partially triangulate this claim.

User 2 also reported that the value of @gemsnet10 was to see how other teachers are "presenting the science lessons." Fourteen codes reflected this. Seven codes reflected NGSS science and engineering practices, part of three-dimensional NGSS-designed instruction. In addition four User 2 codes reflected pedagogical knowledge.

Twice, User 2 codes discussed NGSS disciplinary core ideas. Finally, User 2 participation in @gemsnet10 reflected a single mention each of pedagogical content knowledge and collaboration. In contrast, User 2 also acknowledged others in a single tweet. However, this intention was not reflected in survey data responses.

At the time of export of data, User 2 had 1113 total tweets/retweets and 101 followers. In addition, User 2 followed 90 other accounts. This profile was approved by User 2 as written.

**User 3.** User 3 reported more than five years on Twitter related to teaching, an "above average" proficiency with technology, and viewing @gemsnet10 without tweeting 2-4 times per week. User 3 reported that the value of participation in the Twitter feed community was based in the ability to "showcase student work" as well as share ideas to learn from others.

Coding somewhat triangulated self-reported data from the survey. Eight instances of "acknowledging others" were noted which corroborated self-reported value of sharing ideas. However, in spite of reports about the value of sharing student work, only one code reflected sharing student work specifically.

User 3 had 11 references coded for a total of 1.64% coverage in NVIVO. At the time of import of data using NVIVO, User 3 had a total of 287 tweets/retweets with 41 followers and followed 14 other accounts. User 3 did not respond to two requests to edit and approve their file.

**User 4.** From survey data, User 4 reported a “slightly above average” proficiency with technology, using Twitter for purposes related to teaching for 1-2 years, and viewing @gemsnet10 without tweeting 1-2 times per week. User 4 reported that the value of participation in @gemsnet10 was “I want to support GEMS-Net.” I had no access to twitter data from User 4, so triangulation of data across Twitter and survey results was impossible.

**User 5.** User 5 reported “above average” proficiency with technology, using Twitter related to teaching for 1-2 years, and viewing @gemsnet10 without tweeting 1-2 times per week.

User 5 reported that participation in the @gemsnet10 Twitter feed community was a valuable way to “keep up with GEMS-Net activities.” User 5 also reported that participation was useful to learn “how other teachers use FOSS kits.” This intention seemed to be reflected somewhat in codes for this user’s tweets. Three out of five codes reflected sharing pedagogical techniques or pedagogical content information. In contrast, the remaining tweets reflected different intentions. One tweet was coded as acknowledging others. Another tweet reflected NGSS science and engineering practices.

User 5 had 67 tweets/retweets at the time of import of data to NVIVO with 29 followers. User 5 followed 93 Twitter accounts. Tweets and retweets imported to NVIVO covered 0.60% of total text. This profile was approved by User 5 as written.

**User 6.** User 6 reported having a Twitter account related to teaching for 1-2 years, and denied having a Twitter account before participation in @gemsnet10. User 6 viewed @gemsnet10 without tweeting 1-2 times per week.

When asked about the value of participation in @gemsnet10, User 6 reported that the Twitter feed community was a vehicle to showcase science instruction in the classroom, school, and community. User 6 also asserted that @gemsnet10 was a vehicle to share ideas among educators for teaching science.

Codes were consistent with survey data for this user. There were four references coded for User 6 (0.60% coverage). User 6 shared resources and student work as well as suggesting methods of pedagogical content knowledge. User 6 also shared information related to NGSS disciplinary core ideas. This profile was approved by User 6 as written.

**User 7.** User 7 reported that the value of participation in the Twitter feed community was “to share lessons/ ideas.” Codes for tweets and retweets supported this statement with a majority of codes reflecting the goal of sharing lessons and ideas.

User 7 shared a total of 70 tweets and retweets (10.43% coverage). The most prolific code for this user (34.3%) was NGSSsp which reflected NGSS science and engineering practices. Next most frequent code (28.6%) was STAIsa, described as sharing activities.

Other codes for User 7 shared ideas for pedagogical knowledge (n=6) and pedagogical content knowledge (n=5). In five instances, information about NGSS disciplinary core ideas were shared. Ten codes acknowledged others’ accomplishments and seven codes showcased student work. A few codes shared resources (n=2) and acknowledged the User’s own accomplishments (n=2).



User 7 also asked a question to the community and shared an opinion. It should be noted that the latter two codes were infrequently used within this Twitter feed community, suggesting a relatively high level of engagement and trust by this User. User 7 did not respond to two requests to approve this profile.

**User 8.** User 8 reported “average” proficiency with technology, had a Twitter account prior to participation in @gemsnet10, and used Twitter related to teaching for 2-3 years.

User 8 reported the value of participation in @gemsnet10 as helpful “to see what others are doing and how they are celebrating students.” Coding evidence was consistent with this report because the User viewed tweets and retweets of other participants more frequently than tweeting or retweeting. Tweeting five times (0.75% coverage) and viewing @gemsnet10 1-2 times per week.

Codes for this User shared NGSS science and engineering practices (n=3) and activities (n=3). User 8 also shared student work (n=1) and pedagogical content knowledge (n=1). This profile was approved by User 8 as written.

**User 9.** User 9 reported having a Twitter account before participation in @gemsnet10 and using Twitter related to teaching for 1-2 years. User 9 reported average proficiency with technology and that they participated by viewing 1-2 times per week without tweeting so this could be consistent with reports of the User to ...“hear about events, be inspired.”

User 9 also reported that the value of participation in @gemsnet10 could be described as to “share ideas, hear about events, be inspired.” Coding of tweets and retweets did not support this statement because there was only one tweet (0.15%

coverage). The tweet was a hyperlink that could not be traced back to Twitter for further clarification. User 9 did not respond to two requests to approve this profile.

**User 10.** From survey data, User 10 reported an account on Twitter for more than five years that related to teaching, but did not specifically reply to the question about having a Twitter account before participating in @gemsnet10. User 10 reported that the value of participation in @gemsnet10 is that one can “see what other classrooms are doing/learning.” Both coded tweets and retweets somewhat supported the reported value of participation in this Twitter feed community for User 10 because the User acknowledged the good work of others.

A breakdown of codes revealed other intentions as well. Most codes for this user were categorized as sharing activities (n=11, 35.5%). The next most frequent code reflected NGSS science and engineering practices (n=8, 25.8%). Other frequent codes related to acknowledging others (n=5, 16.1%) and NGSS disciplinary core concepts (n=5, 16.1%) Another frequent code referred to showcasing student work (n=4, 12.9%). There was one reference each to NGSS phenomenon, acknowledging good work of self, and sharing pedagogical knowledge.

User 10 had a total of 31 references in NVIVO which yielded a relatively high amount of coverage (4.62%) compared to other users. User 10 did not reply to two requests to approve this profile.

**User 11.** User 11 viewed the Twitter feed community 0-1 times per week and used Twitter related to teaching for 3-4 years, even before participation in @gemsnet10. User 11 reported an “above average” proficiency with technology.

User 11 data was not imported to NVIVO from Twitter. Therefore, survey data

did not support themes of codes. However, through survey data User 11 reported that the value of participation in @gemsnet10 was in learning about science education all over the state by keeping in touch with the parent organization. User 11 did not respond to two requests to approve this profile.

**User 12.** User 12 reported an average proficiency in technology use. They used Twitter related to teaching purposes for 0-1 years and reported having no Twitter account before participating in the @gemsnet10 community.

Codes associated with this User 12 were related to acknowledging others and sharing resources. Coding from tweets and retweets supported User 12's assertion that participation in @gemsnet10 was useful for educational opportunities, professional development, and professional contacts.

There was only one tweet (0.15% coverage) but the user viewed the Twitter feed community 0-1 times per week without tweeting. This profile was approved by User 12 as written.

## **Summary of Chapter 5**

For Users 1, 4, and 11, I had difficulty accessing data even though they completed the survey. In one case, the email address given by the User did not work. Another of these Users had no Twitter data. Excluding Users 1,4, and 11, there was at least partial agreement among coded tweets and a report by the user about the value of @gemsnet10.

My intention was that all survey responders would be given the opportunity to approve, edit, reject, or add to their profile. Member-checking is an accepted way of adding validity to qualitative research (Patton, 2002). However, this was not always how events transpired. Users 1, 4, and 11 did not have the opportunity to read their profile

because of incomplete or inaccurate information that prevented transmission of the file to them. Users 2, 5, 6, 8, and 12 approved their respective profiles as written. Users 3, 7, 9, and 10 did not respond to two requests for reading and approving their profile.

Survey data was valuable for this study because it provided another way to answer the question, “What is the value of participation in @gemsnet10 for you?” The first way to investigate this question was to code tweets and retweets for themes directly from imported data of @gemsnet10 to NVivo. However, in the survey, I could directly ask this question. Even better, I could compare the two types of responses to see if they were in agreement, giving me more confidence in my coding process. Although some information was incomplete or inaccessible, I found the process valuable for this study.

## CHAPTER 6

### DISCUSSION, CONCLUSIONS, IMPLICATIONS, LIMITATIONS, AND REFLECTIONS

#### **Introduction to Chapter 6**

The purpose of this study was to contribute to research about how online Twitter communities can help support science teachers in their professional practices, especially in times of reform. To accomplish this, I analyzed interactions of teachers in an established, ongoing, voluntary Twitter feed community through a lens of affinity identity (Gee, 2000) to uncover themes, frequencies, and patterns of tweets and retweets and to look for evidence of professional online interactions that supported science teacher knowledge, reform practices, and affinity identity with others in the Twitter community.

Chapter 6 will discuss conclusions of the study both for the community as a whole and for individual users who offered to share the value of their participation in the Twitter Feed Community. I will make connections between findings of this study and learning in social communities with an emphasis on theories about learning in digital communities. Furthermore, I will discuss implications about my findings for professional development for teachers, especially in times of reform. I will make recommendations for participation in Twitter feed communities and the value of that participation for teachers with regard to professional support in times of reform and also with regard to strengthening science teacher identity through participation in a community, specifically a Twitter platform. In the next section, conclusions were organized under corresponding research questions.

## **Conclusions: Research Question #1 and Sub-questions**

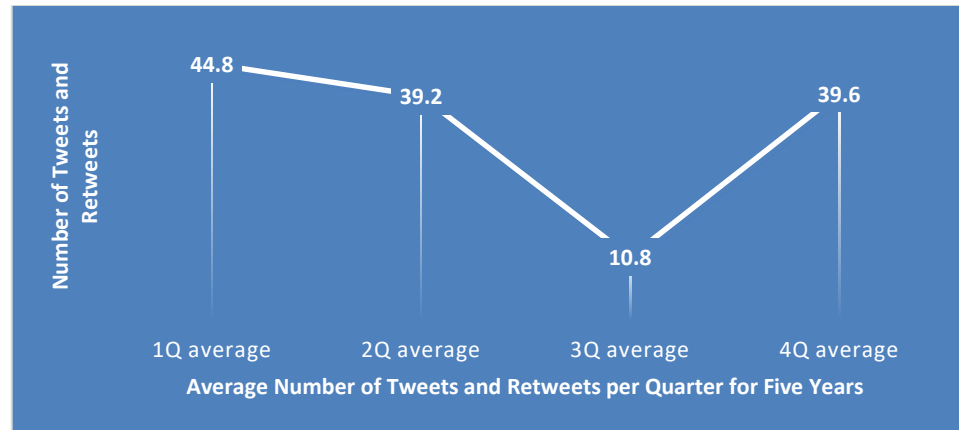
**Characterization of the community as a whole.** Several different types of stakeholders have followed @gemsnet10. A breakdown of professions yielded 12 different declared professions, suggesting that followers may have different reasons for joining the community. For example, some of the earliest followers seemed to be following @gemsnet10 for business-related reasons, perhaps to market educational supplies. In fact, there was a general trend regarding Twitter followers for @gemsnet10. Many early followers seemed to be business-oriented with teachers joining later. There were some exceptions to this general rule, with some members of GEMS-Net as early followers of the community. Teachers, on the average, joined Twitter (not to be confused with following @gemsnet10) within months of the start of data collection for this study. However, there was great variability in this data, with some teachers recently joining Twitter and others joining Twitter as long as seven years ago. The largest group of followers were teachers.

Other followers seemed to be involved in the Twitter feed community to market their own businesses. For example, personal trainers and educational activists shared information about themselves and their own professional endeavors. Still others, such as politicians, librarians, and undergraduate students could be grouped as interested in following the parent organization, which has been established for over two decades in supporting elementary science teachers. GEMS-Net is considered to be one of the educational leaders in the State and has a reputation of supporting student understanding in science by supporting their science teachers through long-term professional development. It would not be surprising that many users of Twitter would follow

GEMS-Net.

**Personal vs. professional interactions.** Surprisingly, of 671 tweets and retweets, only one tweet discussed any kind of personal information. The tweet showed a picture of a participant's child. However, the accompanying text conveyed the message that the child was having fun at a GEMS-Net sponsored event. Assuming that the tweet was also being used for marketing the event, I concluded that nearly 100% of tweets and retweets in this study were professional in nature. This finding seems to suggest that followers of @gemsnet10 were complicit in using the Twitter feed community solely for professional reasons.

Other data that lend support to this conclusion that @gemsnet10 members perceived the community to be related to their teaching careers are pictured in Figure 6.1. Average number of both tweets and retweets for each quarter were averaged over five years. The graph shows a steep decline in the number of tweets and retweets in the third quarter which is consistent with the time of year when teachers are not typically in class or when teachers are establishing a classroom culture for the new school year and may be least likely to have time for posting on Twitter. From this graph, tweeting and retweeting in @gemsnet10 seem to be associated with their teacher practice.



*Figure 6.1* Number of tweets and retweets for each quarter over five years.

**Themes of tweets and retweets.** Codes were assigned in the early stages of data analysis. I re-assigned codes as necessary to accurately reflect themes of tweets and retweets. This follows the procedure for content analysis that was outlined in Richards (2015). I came to understand the process of moving in and out of the data, at first taking a broad look at themes, then moving in to continually sort one type of theme from another.

Eventually, categories of themes emerged. Fifteen categories emerged for Twitter data of the entire community, with another three emerging from survey data, to be discussed later in this chapter. Of the fifteen categories from Twitter data, there were three broad classifications: (a) reform codes, used to label themes related to NGSS, (b) sharing codes, used to label intent to share information, resources, etc. with other members of the community, and (c) science teacher knowledge codes related to content knowledge, pedagogical knowledge, pedagogical content knowledge, and invitations to collaborate with other teachers to enhance science teaching.

Sharing codes described above can be related to identity formation, according to



Gee (2000). Gee explained that the act of sharing in a group contributes to affinity with other group members. Of the top five most frequent codes, three were sharing codes. Sharing resources, activities, and student work were prevalent themes. Particularly noteworthy is the most prevalent code, STAlao, or “science teacher affinity identity-acknowledging others.” This code was present from the first quarter of data collection and in every other quarter except for the last two quarters of the first calendar year (when there was no data). Gee (2000) discussed sharing in his definition of affinity identity. He defined affinity identity as identity that gains power through affiliation with a group. This data suggests that affinity identity forms when community members share something of value with other members. Survey results from individual users suggest that some followers of @gemsnet10 participate in this Twitter feed community because they recognize that other followers share valuable information such as resources and lesson ideas.

I was surprised that members acknowledged the good work of others from the first quarter of data collection and consistently throughout. I expected affinity identity to build over time. Therefore, I expected frequency of sharing codes to build over time. Then I realized that there may have been some carry-over of affinity identity that had already formed from early members of GEMS-Net and their affiliation with GEMS-Net. Also, Gee (2000) describes another type of identity, institutional identity, as identity that gains power from affiliation with an institution. Perhaps followers of @gemsnet10 had affinity with other followers partially through recognizing the identities of others as teachers deemed worthy of employment through an institution. A breakdown of number of tweets and retweets for all codes, with an overlay depicting percent coverage for each

code as related to total coded text can be found in Figure 6.2.

The second most prevalent theme was NGsp, or “NGSS Science and Engineering Practices.” The parent organization for @gemsnet10 Twitter feed community, GEMS-Net has offered 2-5 sessions of professional development per year and GEMS-Net teachers (F2F) are required to attend at least one per year (personal communication with Sara Sweetman, January, 2019). One of the goals of GEMS-Net is to provide support to practicing science teachers in their network regarding implementation of NGSS-aligned FOSS Kits (see Appendix E for GEMS-Net Sequence of Foss Courses). FOSS emphasizes hands-on inquiry. Therefore, it is expected that members of @gemsnet10 would be comfortable sharing activities and student work that reflect the skills listed in Framework for Science Education (NRC, 2012) as Science and Engineering Practices, for example, analyzing and interpreting data or obtaining, evaluating, and communicating information.

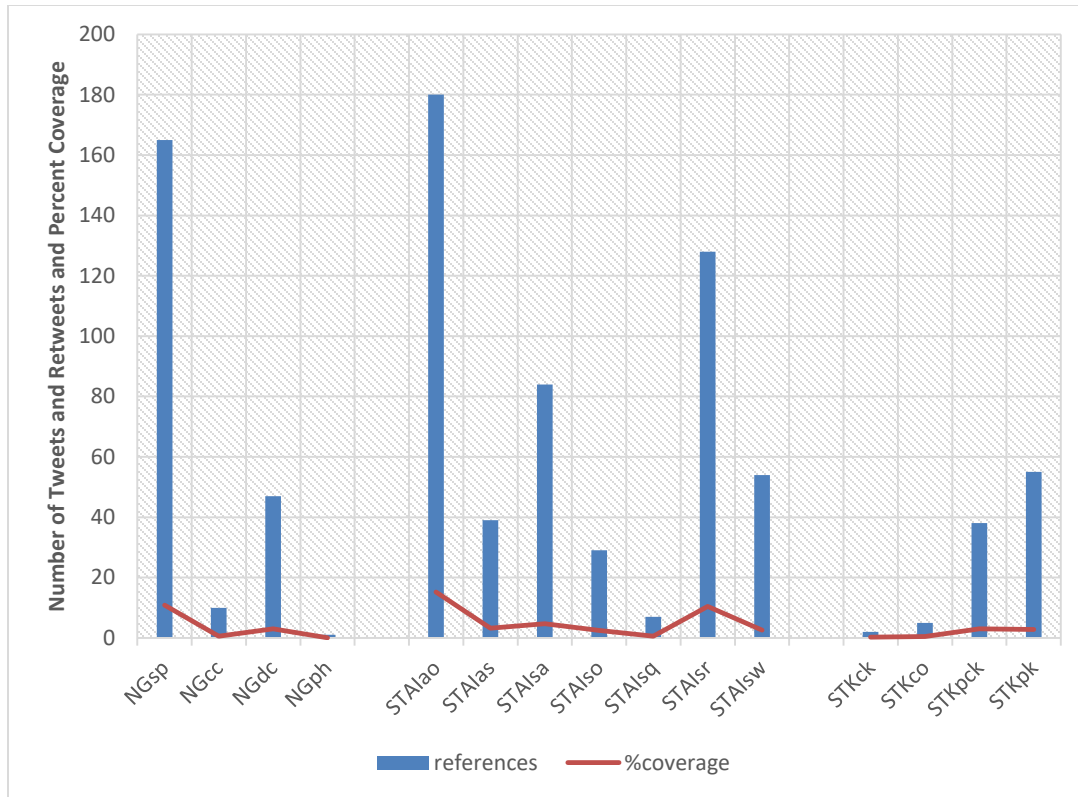
The third most prevalent theme, coded as science teacher “affinity identity- share resources” is the willingness of @gemsnet10 members to share resources of all kinds. Resources varied but some common types of resources were event information or curriculum-related resources such as informational texts or educational supplies. Resource sharing is yet another example that could be viewed through Gee’s definition of affinity identity because when a member deems a resource as valuable, then this resource will not be shared with others in a group unless the sharer feels that the resource will be valued by other members of the group. Since @gemsnet10 members give some indications that they are a professionally-oriented group, the stakes may be too high for sharing of random resources. Therefore, I conclude that members of @gemsnet10

display the behavioral attributes of an affinity group inclusive of the discourse and community digital artifacts.

Gee (2001) describes identity as contextual so affinity identity with other members of @gemsnet10 may wax or wane depending on the last tweet. Gee also describes identity as fluid, or changeable. Data suggest that at least some members at sometimes feel a strong enough affinity with other group members to share resources that they most likely feel are valuable to other members of @gemsnet10.

The fourth most prevalent code is another sharing code: “science teacher affinity identity- sharing activities.” This code was assigned when teachers shared activities of students, whether in the classroom, or less often in an outdoor classroom or a physical setting other than an indoor classroom or school building. Images and/or video oftentimes accompanied this code. Teachers sharing activities often seemed pleased with the results of student engagement and the creation of student artifacts. The activities code was used when students were engaged in work that was related to science but could not be explicitly linked to one or more dimensions of NGSS.

The fifth most prevalent code is STKpk, defined as “science teacher knowledge-pedagogical knowledge.” This code was used to describe when teachers gave other @gemsnet10 members information about teaching methods for science instruction.



*Fig 6.2. Comparison of Code Frequencies and Percent Coverage for Twitter data.*

**Affordances of twitter used to enhance connection.** There was a frequent intention to connect with other Twitter feed community members. Eighty-three percent of interactions were in the form of retweets. As stated previously, Union Metrics Blog (2016) suggested that Twitter users retweet information that they consider valuable to other users in some way. If users read a tweet, consider it valuable, and have nothing to add, they may retweet. If this is so, most interactions were deemed valuable because they were retweeted.

Another affirmation of intention to connect among Twitter feed community members of @gemsnet10 was through the use of hashtags and mentions. Hashtags were part of 24% of all tweets and retweets and were used to collect tweets and retweets in a

common digital space by topic. In addition, Mentions were part of 22% of all tweets and retweets. Users add mentions, for example, @RelevantScience, in a Tweet specifically for adding the tweet or retweet into another user's timeline. This has the effect of increasing accessibility for the recipient. If the recipient quickly scans their own timeline regularly, they will likely see tweets with a mention of their username. Moreover, if they have notifications available for Twitter on their phone, the tweet will be visible in a notification, with a number marker on the Twitter icon to let the user know that there is a notification.

There can be no discussion of connection without discussing an antithetic role in the community, the phenomenon of "lurking," which is a term used to describe a person on social media who does not post, only views the posts of others . In this community, I documented a significant number of lurkers because when NCapture imported Twitter data into NVIVO, only 97 usernames appeared out of 292 authentic followers. I assumed that there were some "protected" accounts that I could not access (I could positively identify four protected accounts.). However, most or nearly all of the followers who were not imported were presumed to be "lurkers." Even though "lurkers" choose not to share, they may participate in other ways, through viewing others' posts. Although the term "lurkers" was discussed a few times, a further discussion and assignment of a new terminology that I have designated for "lurkers" and implications of the term for the @gemsnet10 community will be discussed in more detail later in this chapter.

Sharrat and Usoro (2003) outlined reasons why people share information online. Trust is one construct that must be in place, as well as ease with the infrastructure of the technological platform. They proposed that "lurking" occurs when impediments prevent

sharing. Presumably, the risk is greater than the benefit. However, I prefer to label those not willing to share information as “spectators,” since they may still be participating by viewing and learning. Many members of @gemsnet10 posted very few tweets. These members could be actively learning without sharing information and opinions of their own.

**Sustainability.** In spite of the fact that participation in @gemsnet10 was voluntary throughout its history, evidence supports an increasingly larger number of followers over time. At the time of this writing, @gemsnet10, has 312 followers, an increase of 6% since December, 2018. The slope of the trend line ( $m=2$ ) suggests that membership has steadily and substantially increased since the inception of the community.

**Value of participation.** From Twitter data, value of participation for the community as a whole seems to be that members of @gemsnet10 use the community first and foremost as a way to acknowledge the valuable work of others. Gee (2000) described this as getting power from a group to contribute to your own identity, in this case, as a science teacher. This is evidenced by the most prevalent code, STAIao, defined as “sharing code-acknowledging others.” Members frequently also shared resources and activities, which also may be seen through a lens of affinity identity. Science and engineering practices as defined by the Framework for K-12 Science Education (NRC, 2012) were often displayed, accompanied by image, video or hyperlink.

Members of @gemsnet10 were least likely to use the context of this digital community for content knowledge. There were only two instances of tweets or retweets coded as “science teacher knowledge- content knowledge.” Likewise, there were only

two tweets or retweets about phenomena, in spite of the fact that NGSS encourages the use of phenomena as a way to engage students in the process of science learning. Both of these least frequent codes were identified in the later years of data collection, in Year 4 and 5.

I concluded from Twitter data that, for the most part, the @gemsnet10 community members valued the community as a way of connecting to members, resources and events. In addition, and slightly secondarily, members of @gemsnet10 used the community as a way of looking into others' classrooms to see activities and student work as well as viewing other teachers' pedagogical methods.

### **Conclusions: Research Question #2 and Sub-questions**

**Changes in frequency of codes over time.** Regarding NGSS codes, NGSSsp (Science and Engineering Practices) generally trended upward in frequency, although it cycled through five years of data collection, dipping every third quarter of each year. This trend reflected a general trend in data as expected from a community of teachers (July, August and September were months that teachers may be least likely to tweet). NGdc (Disciplinary Core Ideas) followed the same trend but with lower frequency, approximately half as frequently as NGsp. The frequency of NGcc (Crosscutting Concepts) reached a peak in Year 2; NGcc was assigned at a low frequency after Year 2 until the end of Year 5. NGph (phenomenon) could not be easily characterized by changes in frequency since there were only two occurrences. The low number of codes for phenomenon could also reflect that it was difficult to code. Even using images and video as backups to characterize the intention of the tweeter, I did not have the privilege of being present for the science lesson. Many images show natural phenomenon but I

had no way of verifying this without explicit mention (and an elementary teacher may be unlikely to do this). This reflects a limitation of the experimental design and will be further discussed in the limitations section in this Chapter.

The general trend above could also be explained by the increase in number of followers throughout the five year span of data collection. However, it seems reasonable to conclude that the NGsp and NGdc codes remained prominent themes as compared to NGph and NGcc. Crosscutting concepts may be likewise biased as a result of this limitation.

Science teacher knowledge codes cycled in frequency with a general trend upward for STKpk (pedagogical knowledge) and STKpck (pedagogical content knowledge). These were the dominant codes of the STK group, as compared to STKco (collaboration) and STKck (content knowledge).

Sharing codes had the opposite patterns to the other two groups of codes. The three most frequent sharing codes (STAIao, STAIsr, STAIsa) peaked in Year One and Two, then had a downward trend. Perhaps the themes related to these codes were safe as affinity identity was forming. Gee (2000) spoke of a recruitment as groups form and gain identity. Perhaps acknowledging the valuable work of others is a way of validating other members and recruiting them into the group.

**Themes of codes over time.** For this research question, I compared percentages of codes relative to other codes in their same group. For example, of the STK codes, when looking at relative percentage of each code per quarter, pedagogical knowledge dominated for 11 of the 20 quarters (five year span) (see Figure 6.3). Pedagogical content knowledge was the predominant theme for 4 quarters. In this case, STKpk theme



remained relatively dominant from Year Two through Year Five, so this theme remained relatively unchanged.

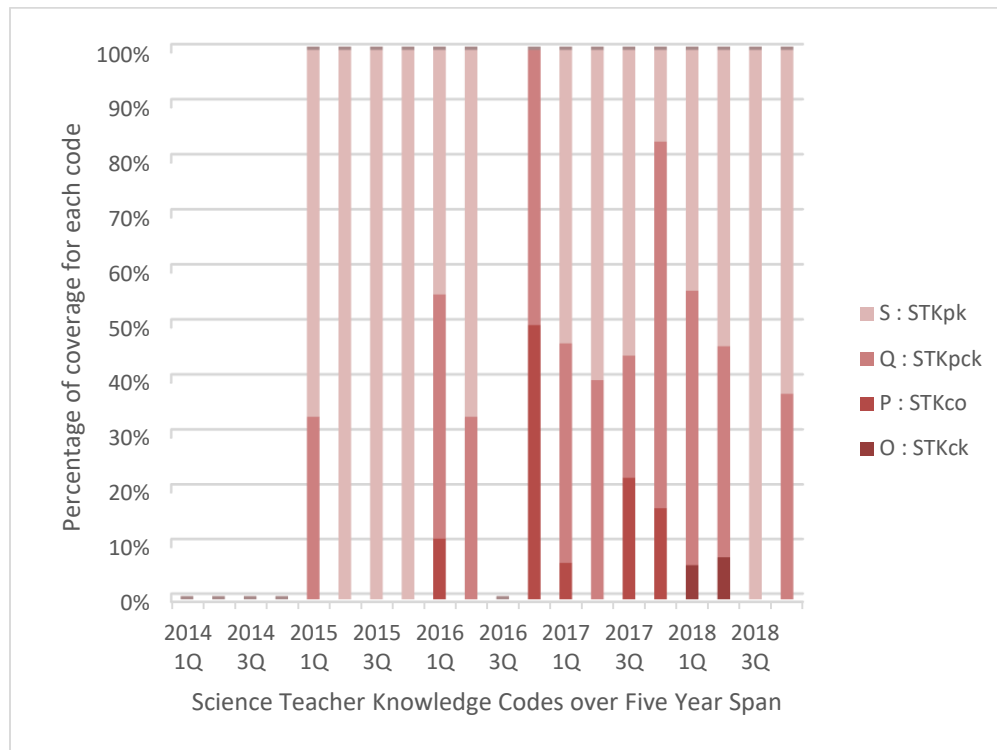
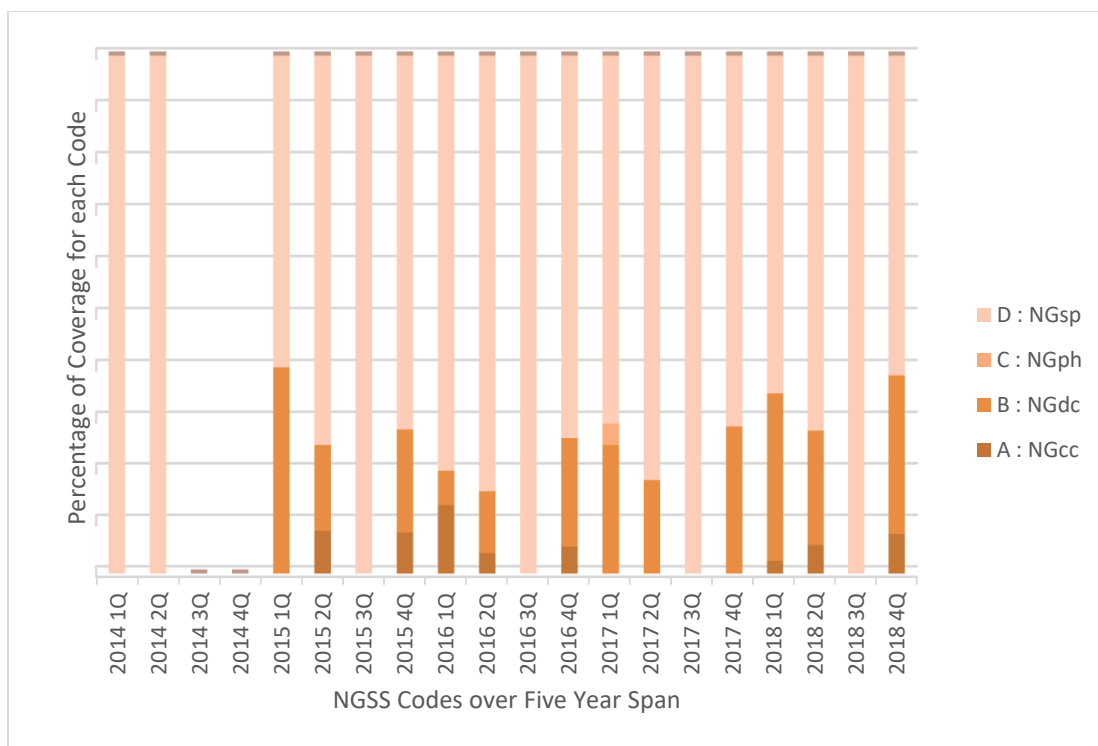


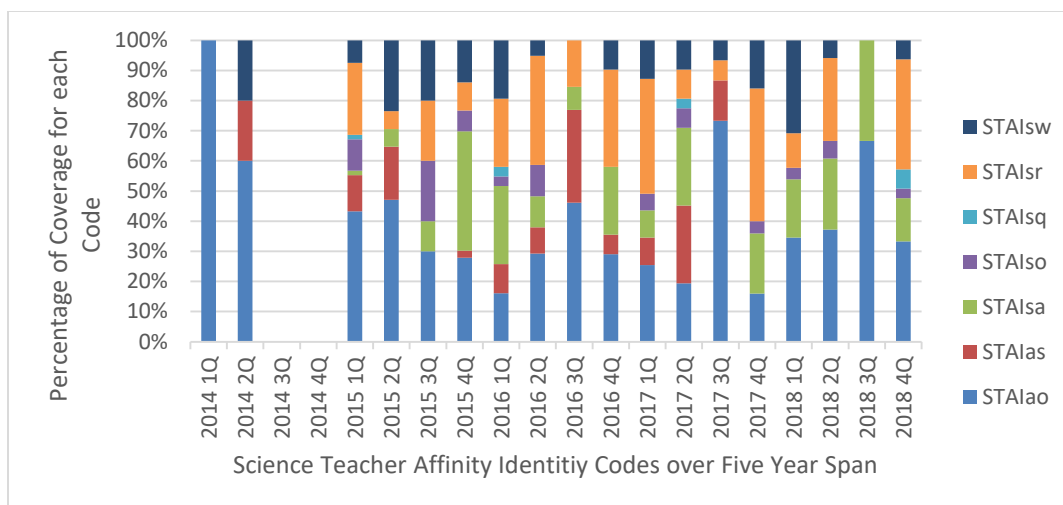
Figure 6.3. Relative percentages of coverage over Five Year Span for STK codes

For NGSS codes, NGsp (Science and Engineering Practices) was the prominent theme throughout the span of data collection. This could be the result of hands-on professional development through GEMS-Net and their support of the use of FOSS kits, which was then modeled for other teachers via the affordances of Twitter in the @gemsnet10 Twitter feed community (see Figure 6.4). Furthermore, science education has focused on inquiry prior to NGSS. Perhaps the most recent decades of hands-on science allowed teachers in this Twitter feed community to be comfortable with science practices such as observation, communication, and asking questions.



*Figure 6.4.* Relative percentages of coverage over Five Year Span for NGSS codes

Science Teacher Affinity Identity Codes remained relatively stable over time. The predominant theme was “acknowledging others” in 11 out of 20 quarters and these quarters were spread out across the five year data span. “Sharing resources” cycled throughout, but was predominant in only five quarters. The general theme remained predominately about “acknowledging others.” (see Figure 6.5)



*Fig 6.5. Relative percentages of coverage over Five Year Span for Science Teacher Affinity codes*

## Conclusions: Research Question #3 and Sub-questions

### Individual reports about value of participation in the Twitter feed

**community.** User profiles were constructed for each of the 12 teachers who were invited to complete a short survey because of their dual association in @gemsnet10 and GEMS-Net. One question was “What is the value of participation in @gemsnet10?” Examples of responses were, “I wanted to be inspired,” Hear about events,” “Sharing ideas, lessons,” “I want to support GEMS-Net.” “See how other teachers use FOSS kits,” “Showcase science instruction in classroom, school, and community,” “ See what others are doing.”

This conclusion was validated by survey results from 12 teachers. When asked “What was the value of participation in the @gemsnet10 Twitter feed community, they responded with these answers. In nine out of 12 User profiles, there was at least partial agreement between the stated value of participation in @gemsnet10 and codes from the User’s tweets. In addition, these responses at least partially validate codes from

the @gemsnet10 community as a whole because a majority of codes from the entire community are about sharing and science practices.

### **Implications of Research**

Bates, Phalen, and Moran (2016) described online professional development as becoming more popular. Some of the reasons they give for this phenomenon may seem obvious. Online platforms can be more efficient than face-to-face sessions because they can be accessible and ready when you are. Many online PD programs are less expensive to administer and maintain.

In my opinion, one of the reasons that @gemsnet10 has been sustainable is that Twitter is accessible and free. Twitter has many affordances that allow for quick posting (up to 140 characters of text when the data for this study was collected). Even better, text can be augmented by images, video and hyperlinks.

Also, the community may have benefited by some measure of trust already established through association of members from GEMS-Net establishing @gemsnet10 (Sharrot & Usoro, 2003). I might be inclined to recommend to anyone who is attempting to create an online community for teacher learning to establish early interactions among members who already have some kind of face-to-face association, especially through a professional association. McConnell, Parker, Eberhardt, Koehler, and Lundeberg (2013) reported that teachers prefer face-to-face professional development, yet it may not be convenient, practical, or affordable. Fogleman et al., (2006) suggested that online PD can be used successfully to sustain content learned in face-to-face PD. This concept may be related to the building of science teacher identity, as in Carlone and Johnson's (2007) model, which includes *recognition* of teachers by others.

Gee's (2000) four types of identities include institutional identity, which gains power through membership in an organization. The @gemsnet10 Twitter feed community had at least some members who began their association with PD in a face-to-face organization, GEMS-Net. These members were credentialed and hired as teachers. Therefore, it seems logical that this could contribute to the basis for an organization that can build additional affinity identity as time goes on.

Tobin (1998) coined the term "professional learning network" or PLN. This community, @gemsnet10, has many characteristics of a PLN but there are important differences. PLNs typically involve dissemination of power from an administrator who convenes the group for a specific purpose. The administrator shares power intentionally to accomplish a specific goal. Other non-goal-oriented goals would likely remain outside the jurisdiction of the PLN. In @gemsnet10, there is no singular clear agenda or power structure. All members have the opportunity for equal access and voice.

At first, I held the concept of "Community of Practice" as a framework to describe this community (Wenger, 1998). However, my thinking changed as I analyzed the data. Wenger described a community of practice as a group having shared domains, shared language, and shared goals. Although this may be true, for the most part, of @gemsnet10, the power structure seems different than a traditional community of practice.

Access on Twitter is equitable so all may contribute if they hold a free account. There is a contextual or "situated" aspect to learning (Lave & Wenger, 1991) where members tweet more or less frequently, so may be assumed to be correspondingly more or less active in the community. However, there is no clear movement from the

periphery to the center of @gemsnet10. In fact, a leader on one day may be an observer the next day. In summary, I view the power dynamic in a Twitter community to be more just, allowing everyone an equal opportunity to tweet their own opinion or retweet the opinions of other members.

### **Limitations**

This study has some limitations. First, because of the qualitative nature of the study, it may very likely lack generalizability. Even though taking a close look at this Twitter community allowed for triangulation of data across text, video, images, and hyperlinks, as well as survey data from individual users, the community was unique in that members met both online and face-to-face. This characteristic may add even further to lack of generalizability beyond GEMS-Net. However, the research does provide some value for novice and expert teachers alike in that it suggests that an ongoing voluntary Twitter feed community holds value as support for teachers adopting new science teacher identities in times of reform.

The most significant limitation of the present study was that I could not verify if participation in the @gemsnet10 Twitter feed community contributed to changes in teachers' beliefs, behaviors, planned curriculum, or active curriculum. Twitter data was imported as a dataset and was effectively a "snapshot" of interactions of participants of @gemsnet10. Further study would be needed using a different experimental design to uncover any of these changes.

Another limitation was that Twitter was used to share lessons, ideas, practices, but these were all indirectly observed. I never observed an actual lesson or interaction first-hand. Data was "captured" and this snapshot was analyzed. This may have limited

accuracy of coding, as I may have missed crucial information in the classroom that was not captured by the Twitter format. Low occurrences of phenomena (NGph) and Crosscutting Concepts (NGcc) codes highlighted this serious limitation in the data. Future research should be done to address this issue using a more appropriate experimental design to detect the more abstract constructs that may have been missed by coding a “snapshot” of a lesson rather than observing the lesson in real time.

### **Reflections and Recommendations**

As a teacher, I am in favor of Twitter as a learning tool and a platform for professional development. This conviction has become stronger after analyzing data from @gemsnet10 teachers. However, I am not naïve in thinking that everyone will embrace this platform. First, some teachers prefer social contact of face-to-face professional development. Others learn best with hands-on methods. Some fear technology. Johnson (2001) recommends adequate scaffolding before expecting people to use technology.

Leuhmann and Tinelli (2008) see technology as a way of trying on new reform identities. Up to 68% of followers of @gemsnet10 were viewing without tweeting or retweeting. Recall that only 93 followers of @gemsnet 10 were imported by NVivo. Therefore, 79 followers may be designated as “Lurkers,” or followers that view but do not tweet or retweet. In my terminology and in the context of this community, these followers may not be “Lurkers,” but rather “Spectators.” I define Spectators as active viewers, much like the audience at a professional sport arena, who are not playing the game but are likely invested in the proceedings. Followers of @gemsnet10 who are Spectators may very well be doing that- viewing several scenarios provided by online

viewing to decide what they will try. Zembylas (2003) describes trying on new identities to reinvent our “teacher-selves.” I define “spectators” as participating in an online community by watching how others do their work and evaluating pedagogy, curriculum, or identity for potential adoption by the participant. Spectators’ identities as reform-minded teachers may change if they view other reform-minded teachers’ activities and decide that they want to adopt the risk of trying out new pedagogies or lessons.

In my proposal for this research, I adapted Carlone and Johnson’s (2007) model of teacher identity. After handling these data, I realized that I needed to add the context of reform to the digital space. I would expect that the context of reform is slowly becoming more pervasive, at least in the states where NGSS has been adopted. Although curriculum developers, administrators, and teachers are still grappling with how to implement NGSS, I believe that the expectation for all of these stakeholders is that at some point in the future NGSS will be fully implemented. My belief at this point is that this expectation must somehow be affecting how teachers’ identities are formed. Perhaps teachers are already beginning to consider what implementation of NGSS will look like in the classroom. Already, some PD programs are delivering information about new pedagogical tools, new assessment techniques, and templates for adapting older curricular resources to align with NGSS.

I have seen evidence of dimensions of NGSS 3-D model discussed and shared in @gemsnet10. For example, SEPs are regularly showcased. Sometimes teachers discuss “patterns” that students are identifying, which is a Crosscutting concept. I have found evidence of discussion on Twitter about topics that can be found in NGSS DCIs, or Disciplinary Core Ideas.



Why not intentionally share video of teachers facilitating 3-D science learning in a PD for other teachers as an example of how all dimensions can be used to facilitate learning. If teachers experienced this, even on Twitter, they may continue to strengthen their teacher identities to more strongly incorporate reform pedagogies.

In my opinion, Twitter with all its affordances can handle this task. Communities such as @gemsnet10 can and should remain voluntary, but some posts can be intentional, sharing resources that aid in the monumental task of changing science education from a culture of “learning about to a culture of “figuring out” (NGSS Lead States, 2013). Collaborations on Twitter of science leaders who are well versed in 3-D NGSS-designed learning should be our next step toward achieving this goal.

By analyzing these data, I conclude that the most significant use of Twitter for this group of teachers has been to enhance their affinity identity with other teachers, both reform-minded and otherwise. My evidence for this conclusion comes from the abundance of sharing among @gemsnet10 members. Gee (2000) describes the act of sharing as building affinity with a group.

Authors of professional development focus almost entirely on science content. But how does one develop a sense of becoming a teacher? Is it by gaining a deep understanding of science content? Is it by developing pedagogies and classroom management techniques that will contribute to a more productive learning experience for their students? Carlone and Johnson (2007) would likely suggest that this is not the whole picture. What is missing is the recognition by self and others that a person is a science teacher. What is missing is the formation of science teacher identity.

Volkman and Anderson (1998) interviewed a first-year chemistry teacher for the

entire year. She reported difficulty becoming the kind of teacher with which she was comfortable. The novice teacher asked herself throughout the year if she should she be a friend to her students or take a strict stance with them. Should she adopt a more traditional teaching role? Should she be the teacher that parents or school administrators wanted her to be or thought she was? Even over content, these are the issues that troubled her.

Twitter has affordances that may help teachers to be recognized as such, which could lead to teachers internalizing that identity as a teacher, or specifically a science teacher. This could be especially valuable during the last wave of reform in science education, NGSS. Tayack (1991) characterized waves of reform that occur periodically in response to education or societal factors. He further described how reforms are less likely to remain in place when teachers are asked to change their way of teaching. Windschitl and Stroupe (2017) advise that NGSS brings a recommendation that not only is the role of a classroom teacher's role shifting toward facilitation of student-driven learning, but administration and students will be asked to make cultural shifts as well. It seems that it would be beneficial in these times for teachers to develop a strong identity as a confident facilitator of NGSS. The GEMS-Net community in this study shows many behaviors and attitudes to support other community members in their professional endeavors.

The characterization of the Twitter feed community known as @gemsnet10 was an interesting process and I sought to define the dynamic that I had witnessed through analysis of the data. I asked myself about similarities and differences to other types of communities from past research. The group of @gemsnet10 followers could definitely

be characterized as a community. They had shared goals, practices and language. Yet they lacked the master and apprentice model of a Community of Practice as described by Wenger (1998). They shared some aspects of a Professional Learning Community but did not have an agenda set by an administrator, which is typical of a PLC. Hord (1997) describes a PLC as an organization in which a principal shares power of decision-making with teachers. Yet, the @gemsnet10 community did not operate that way. Professional Learning Networks (PLNs) use technology to collaborate on a specific agenda (Jackson & Temperley, 2007) but @gemsnet10 was responsive to tweets and retweets regardless of agenda.

I defined @gemsnet10 using a new term, Semiotic Identity Space (SIS). The term Semiotic referred to communicating using symbolic text, images, and video, rather than face to face, which is borrowed from Gee (2005). Identity refers to the process of collaboration and sharing that seems to develop an affinity among group members as fellow science teachers. Of course, Space is an accessible, free, and democratic entity constantly available and responsive to contributions from community members.

Gee (2005) characterized a Semiotic Social Space, or SSS, to define a group of video game players on a digital platform. He describes a fluid hierarchical structure and leadership framework. The community of @gemsnet10 users shares some characteristics with the SSS. Learning can be focused or generalized. Members seem to be forming an affinity identity with other members.

However, there are important differences between the SSS and SIS. I found no evidence of a hierarchy and no clear indication of leadership roles, even among the most prolific tweeters of the SIS, characteristics that are often included in descriptions of CoPs

(Lave & Wenger, 1991). Gee described the SSS as having fluid and dynamic hierarchy and leadership roles. This was not evident in the SIS. The SIS had a democratic framework, so much so, that I considered naming the community as an SIDS, with the “D” representing democracy. All had an equal voice. Participants chose to share, but not as an expert per se. My impressions of the Twitter feed community in the present study for the most frequent codes were showing support for other participants as a member of an affiliated group. Primarily, the “work” of @gemsnet10 was to build affinity identity with a group rather than to accumulate content knowledge. In contrast, in the case of Gee’s SSS, power comes from content information, especially as competition increases.

Both Gee’s SSS and my SIS could be characterized as “spaces” because they are located in a digital designation, not a physical location as in the case of a traditional CoP.

Furthermore, in addition to developing an affinity identity within the group, there may have been some degree of institutional identity. Gee (2001) defined institutional identity as identity where power comes from a system, such as an affiliation with a school system. Therefore, the designation of an essential construct of *identity* in the SIS emphasizes that the central core of this semiotic space is for the development of identity. Gee (2005) points out that in a SSS, affinity identity is being developed as interactions take place, but he places more of an emphasis on learning of content. I do not see evidence for this in the present research study. Therefore, SIS seems to be the most precise moniker for the @gemsnet10 community.

Perhaps this new model of a community, a SIS, could be one answer to long-term, sustainable and relevant PD (Garet et al., 2001) that is needed to support teachers in their implementation of NGSS and their attempts to facilitate student understanding in science.

The danger would be to impose policies or directions upon a SIS community which may threaten participants' agency and inhibit the perception of relevance to participants.

Further research is needed to find other communities' similarities and differences to the SIS as a tool for teacher support in the implementation of science teaching and specifically NGSS.

This research is only the beginning of a new area of exploration in teacher support and PD. My study provided one type of model for effective online PD, specifically on a Twitter platform. Data from this research indicated that there is promise for communities such as @gemsnet10 to provide ways of building reform-minded science teacher identity and other types of support for science teachers in times of reform. Using a SIS model, for example, a cohort of teacher candidates who have shared face-to-face instruction may benefit from participation in a Twitter platform of novice and expert teachers throughout their professional careers.

## APPENDICES

## APPENDIX A

### Recruitment Letter

GEMSNet Twitter feed Community member,

The following is a brief explanation of an online research study being conducted as part of the requirements for my dissertation so that you can determine if you would like to participate in this study.

The purpose of this study is to see if participation in the @gemsnet10 Twitter community helps teachers to teach science in grades K-12. For this study, your participation in the Twitter community can be defined in many ways. Whether you are simply reading the tweets of others, sharing tweets and retweets of others, or tweeting original ideas, your participation is valuable to the study. You will be considered eligible to participate in the study if you are at least 19 years of age or older and if you are a practicing teacher.

If choosing to participate in this study, you will be asked to complete a short survey (about 15 minutes long) about your participation in the @gemsnet10 Twitter community and your history of Twitter use. The survey will be voluntary and you may stop at any time.

Your user name will be changed before data is shared. Your answers will never be linked with your user name and will only be used for research purposes.

After the study is complete, you will be asked to read a summary of your user profile of participation in the @gemsnet10 Twitter community to check for accuracy. Your profile will be constructed using a summary of your tweets, retweets, and survey results. You will be permitted to edit your profile for accuracy until you are satisfied that the user profile accurately reflects what participation in the @gemsnet10 Twitter community means to you.

It is important to understand that no matter how often you tweet or even read the tweets of others, your participation in the research will be valuable to this study.

There are no minimum requirements for participation in the Twitter community in order to complete this survey. Regardless of how often you tweet or how often you observe the @gemsnet10 Twitter community, what is important is that you accurately represent your involvement by answering the survey questions as best you can.

Participation is totally voluntary and you may choose to stop at any time. Your decisions with regard to this study will not be held against you. You will not lose any benefits by refusing to participate in the study. Study results will be available to you and the benefit of this is that you may learn how others use the @gemsnet10 Twitter community for their

science practice.

The entire study will only take about 30 minutes of your time- 15 minutes for the survey and 15 minutes to read and edit or approve your user profile.

Important: This research has been approved by the University of Rhode Island Institutional Review Board. The principal investigator who is supervising this research is Jay Fogleman, Ph.D. If you have any questions before you click on the link to take you to the survey, please use the contact information below:

Susan P Unger (dissertation researcher) [susan\\_unger@uri.edu](mailto:susan_unger@uri.edu)

Jay Fogleman, Ph.D. (principal investigator) [fogleman@uri.edu](mailto:fogleman@uri.edu)

PLEASE CLICK THE FOLLOWING LINK TO READ THE CONSENT FORM AND GET TO THE SURVEY:

<https://1drv.ms/w/s!AmZiDOPNEoiOgR9lkm28EXTLWhW8>



## APPENDIX B

### CONSENT FORM FOR RESEARCH

**STUDY TITLE:** Analysis of a Twitter Feed of Practicing Reform-Minded K-8 Science Teachers

#### PRINCIPAL and SECONDARY INVESTIGATORS

Principal Investigator: Jay Fogleman, Ph.D. Office (401)874-4161 Email: fogleman@uri.edu

Secondary Investigator: Susan Unger, M.S. Cell (401)419-0185 Email: susan\_unger@uri.edu

#### KEY INFORMATION

Important information to know about this research study:

The purpose of the study is to find out if participation in the @gemsnet10 Twitter community helps teachers to teach science in grades K-8.

If you choose to participate, you will be asked to complete a nine-question survey. This will take approximately 15 minutes. Your responses will be used to create a user profile that describes your use of the Twitter feed and the value of this use for your teaching practice.

There are no anticipated risks or discomforts from this study.

There may be benefits from this study related to your teaching practice if we find that participation in the @gemsnet10 Twitter feed community is valuable to help teachers to teach science in grades K-8.

You will not be compensated for your participation in this study.

You will be provided a copy of this consent form.

Taking part in this research project is voluntary. You don't have to participate and you can stop your participation at any time.

#### INVITATION

You are invited to take part in this research study. The information in this form is meant to help you decide whether or not to participate. If you have any questions, please ask.

Why are you being asked to be in this research study?

You are being asked to be in this study because you are listed as a user in the @gemsnet10 Twitter community. It does not matter how often you participated. In fact, you are still invited to be in this study if you rarely tweeted or have only tweeted one time. You must be 19 years of age or older to participate.

What is the reason for doing this research study?

Teachers of science could sometimes use support to help them teach students in grades K-8. This Twitter community (@gemsnet10) has been in existence since January, 2014. There is no required participation and yet teachers still participate. The investigators are interested to learn what teachers are talking about in the Twitter community and what this Twitter community means to its participants.

What will be done during this research study?

The secondary investigator will read tweets and retweets from the @gemsnet10 Twitter community (from January, 2014 through October, 2017) to organize them into themes. The secondary investigator will also look at how often users tweeted and if patterns changed over time.

If a K-8 practicing science teacher tweeted at least once during this time period, he or she will be asked a few survey questions about what the Twitter community means to them.

A user profile will be constructed based on theme and frequency of tweets as well as survey answers for each user. Each user will be asked to read only their profile (estimated time commitment = 15 minutes) to see if the profile accurately reflects what the Twitter community means to the user. User names will be changed before data is shared with others.

What are the possible risks of being in this research study?

There are no known risks to you from being in this research study.

What are the possible benefits to you?

You are not expected to get any direct benefit from being in this study.

What are the possible benefits to other people?

Researchers may find evidence that teachers value participation in a Twitter community such as @gemsnet10 to support science teaching in grades K-8.

What are the alternatives to being in this research study?

There are no alternatives to participation in this study. However, participants may opt out of the study with no penalty of any kind.

What will participation in this research study cost you?

There is no cost to you to be in this research study.

Will you be compensated for being in this research study?

There will be no compensation for participation in this research study.

What should you do if you have a problem during this research study?

Your welfare is the major concern of every member of the research team. If you have a problem as a direct result of being in this study, you should immediately contact one of the people listed at the beginning of this consent form.

How will information about you be protected?

Reasonable steps will be taken to protect your privacy and the confidentiality of your study data. User names will be changed before data is shared with others.

The data will be stored electronically through a secure server and will only be seen by the research team during the study and for five years after the study is complete.

The only persons who will have access to your research records are the study personnel. The information from this study may be published in scientific journals or presented at scientific meetings but the data will be reported as group or summarized data and your identity will be kept strictly confidential.

What are your rights as a research subject?

You may ask any questions concerning this research and have those questions answered before agreeing to participate in or during the study.

For study related questions, please contact the investigator(s) listed at the beginning of this form.

For questions concerning your rights or complaints about the research contact the Institutional Review Board (IRB) or Vice President for Research and Economic Development:

IRB: (401) 874-4328 / [researchintegrity@etal.uri.edu](mailto:researchintegrity@etal.uri.edu).

Vice President for Research and Economic Development: at (401) 874-4576

What will happen if you decide not to be in this research study or decide to stop participating once you start?

You can decide not to be in this research study, or you can stop being in this research study (“withdraw”) at any time before, during, or after the research begins for any reason. Deciding not to be in this research study or deciding to withdraw will not affect your relationship with the investigator, the University of Rhode Island, or GemsNet.

You will not lose any benefits to which you are entitled.

## ONLINE SURVEY CONSENT

I have read and understand the above consent form. I certify that I am 19 years of age or above and a practicing science teacher and participant in the @gemsnet10 Twitter community. By clicking the submit button to enter the survey, I indicate my willingness to voluntarily take part in the study.

## APPENDIX C

### SURVEY QUESTIONS (based on Carpenter, 2015)

Q 1: What is your Twitter username (sometimes referred to as your Twitter handle)?

Q 2: What is your preferred email?

Q 3: How many years have you been teaching?

Q 4: What grade(s) have you taught or are you presently teaching?

Q 5: Why do you choose to participate in the @gemsnet10 Twitter community? You may have more than one answer to this question. Please list all reasons. Please be as detailed as possible.

Q 6: Generally, how would you describe your proficiency with technology? (Well Below Average, Below Average, Slightly Below Average, Average, Slightly Above Average, Above Average, Well Above Average)

Q 7: Did you have a Twitter account prior to participation in the @gemsnet10 Twitter community?

Q 8: What is the total amount of time you have been on Twitter related to teaching? 0-1 years, 1-2 years, 2-3 years, 3-4 years, 4-5 years, 5+ years

Q 9: How often (per week) do you view the @gemsnet10 Twitter community without tweeting? 0-1 times, 1-2 times, 2-4 times, 5-7 times, more than 7 times

## APPENDIX D AUTOCODE SEARCH TERMS

### Autocode Search Terms for NGSS DCIs

Disciplinary Core Ideas (DCIs) Grades K-8	Search Terms for Initial Coding
Earth Science	Patterns, sun, moon, wind, water, maps, weather, plants, animals, living, air, resources, environment, stars, orbit, rotation, features, landscape, ice, organisms, gravity, rocks, soil, sediments, earthquakes, volcanoes, ocean, underground, energy, fuels, interior, plate tectonics, unifying theory, geology, maps, erosion, landscape, features, biosphere, renewable, natural hazards, engineer, global warming, climate, record, fossil, diversity, extinction, record, solar system, Milky Way, galaxies, gravity, eclipses, lunar phases, seasons, rock strata, record, water, cycles, density, currents, weathering, atmosphere
Life Science	Organisms, functions, parent, offspring, animals, plants, water, light, sense, communicate, information, behavior, grow, survive, pollination, seeds, range, internal, external, structures, reproduction, life, cycles, repair, motion, sunlight, survival, sense, receptors, perception, memories, web, decomposers, die, defend, cope, inherited, fossils, species, habitat, artificial, selection, advantage, body functions, genetic, environment, sugars, molecules, sense receptors, nerve cells, brain, memories, interactions, living, non-living, predatory, mutual, beneficial, anatomical, mutations, parents, traits, genes, health, integrity, compete, ecosystem, producers, consumers, decomposers, evolution, cells, tissues, organs, behavior, growth, populations, competitive

Physical Science	Matter, properties, chemical, reactions, substances, unbalanced forces, sound, light, electrical, converted, stored, plants, energy, sunlight, fuel, food, amplitude, wavelength, patterns, surface, eyes, encode, send, receive, decode, flows, cycles, atoms, molecules inputs, waves, conserved, released, absorbed, mass, kinetic, physical, temperature, transmit, signals, frequency
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#### Autocode Search Terms for NGSS SEPs

Science and Engineering Practices (SEPs) Grades K-8	Search Terms for Initial Coding
Practice 1: Asking questions and Defining Problems	Questions, experiences, information, natural, designed, investigation, object, tool, variable, testable, process, system, materials, time, cost, observation, phenomena, models, identify, relationships, independent, design problem, dependent, variables, hypothesis, principles
Practice 2: Developing and Using Models	Experience, model, object, process, event, identify, features, difference, amounts, relationships, scales, patterns, object, tool, design, solution, variables, frequent, principle, diagram, prototype, relationships, interactions, limitations, component, simple systems, phenomena, natural, inputs, outputs
Practice 3: Planning and Carrying Out Investigations	Experiences, test, data, plan, conduct, investigation, evidence, trials, evidence, phenomenon, design, solution, variable, object, tool, process, collaboratively, individually, dependent, controls, tools, evaluate, experimental, goals, accuracy, evidence, solutions, conditions
Practice 4: Analyzing and Interpreting Data	Collecting, recording, sharing,

	observations, pictures, drawing, writing, patterns, relationships, analyze, data, multiple, trials, similarities, differences, logical, reasoning, math, problem, evaluate, quantitative analysis, correlation, causation, graph, map, chart, table, statistics, probability, digital tools, characterize, limitations, measurement error, precision, accuracy, methods, operational range, process, system
Practice 5: Using Mathematics and Computational Thinking	Counting, numbers, identify, describe, patterns, natural, design, relationships, graph, chart, algorithm, alternative, solution, engineering, digital tools, solutions, mathematical representations, ratio, rate, percent, basic operations, algebra, scientific, questions, problems, arguments, test, compare, engineering
Practice 6: Constructing Explanations and Designing Solutions	Observations, evidence, tools, materials, design, problem, solution, relationships, measurement, pattern, construct, criteria, explanation, qualitative, quantitative, valid, reliable, theories, laws, natural, world, constraints, scientific, ideas, principles, construct, revise, phenomena, events, reasoning, conclusion, tradeoffs, testing
Practice 7 Engaging in Argument from Evidence	Arguments, evidence, explanations, listen, agreement, disagreement, claim, object, effectiveness, tool, solution, facts, judgment, research, findings, speculation, respectful, critique, peers, data, cause, effect, merits, solution, criteria, constraints, compare, critique, similar, different, facts, models, design, interpretations, questions, support, refute
Practice 8 Obtaining, Evaluating, and Communicating Information	Read, grade-appropriate, texts, scientific, technical, media, engineering, tables, charts, graphs,



	phenomena, solutions, orally, ideas, patterns, natural, designed, world, presentations, claims, findings, gather, oral, synthesize, data, hypothesis, conclusions, scientific, technical, competing, information, accounts, writing,
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#### Autocode Search Terms for NGSS CCCs

Science and Engineering Practices (CCCs) Grades K-8	Search Terms for Initial Coding
Patterns	Patterns, natural, designed, observed, phenomena, evidence, similarities, differences, sort, classify, objects, products, change, cycles, predictions, macroscopic, atomic, rates of change, natural, human, designed systems, cause, effect, graphs, charts
Cause and Effect	Events, observable, patterns, evidence, support, refute, ideas, causes, relationship, observable, change, regularity, effect, correlation, complex, natural, design, scale, systems
Scale, Proportion and Quantity	Relative, scales, bigger, smaller, hotter, colder, models, systems, large, small, units, measure, physical, quantities, weight, time, temperature, volume, time, space, energy, proportional, relationships, magnitude, properties, processes, algebra, expressions, equations
Systems and System Models	Objects, organisms, parts, whole, functions, individual, system, components, interactions, natural, designed, inputs, processes, outputs, energy, matter, information, flows, limitations
Energy and Matter	Objects, pieces, smaller, larger, change, shapes, energy, particles, conservation, thermal, motion, designed, natural, atoms, cycling, matter, transfer, energy, system
Structure and Function	Shape, stability, structure, natural,

	designed, object, function, materials, substructures, shapes, parts, functions, microscopic, structures, systems, function, materials, shaped, used
7. Stability and Change	Things, same, change, slowly, rapidly, measure, change, differences, rates, stable, complex, stability, change, natural, designed forces, scales, dynamic, equilibrium, events, gradual, accumulate, time

## APPENDIX E

### GEMS-NET SEQUENCE OF FOSS COURSES

	Earth Science	Physical Science	Life Science
K	Trees and Weather	Materials and Motion	Animals 2X2
1	Air and Weather	Sound and Light	Plants and Animals
2	Pebbles, Sand and Silt	Solids and Liquids	Insects and Plants
3	Water and Climate	Motion and Matter	Structures of Life
4	Soils, Rocks and Landforms	Energy	Environments
5	Earth and Sun	Mixtures and Solutions	Living Systems
6	Weather and Water	Electromagnetic Force	Diversity of Life
7	Earth History	Chemical Interactions	Populations & Ecosystems
8	Planetary Science	Gravity and Kinetic Energy	Heredity & Adaptation
		Waves	Human Systems Interactions

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